



(51) International Patent Classification:
H01L 31/04 (2006.01)

(21) International Application Number:
PCT/JP2010/005173

(22) International Filing Date:
23 August 2010 (23.08.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2009-225999 30 September 2009 (30.09.2009) JP

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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, 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, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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.

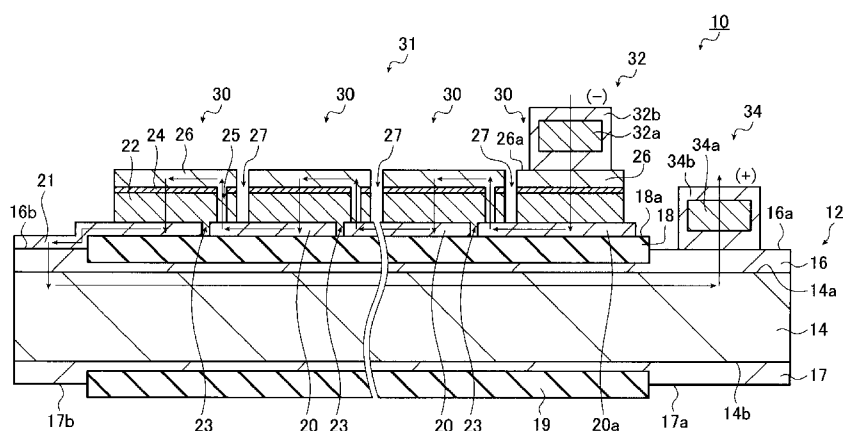
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: PHOTOELECTRIC CONVERTER

[Fig. 1]



(57) Abstract: A photoelectric converter includes a metal substrate having a conductive portion and an electrical insulation layer formed on at least a surface thereof, a photoelectric conversion device formed on the insulation layer, a first conductive member connected to one electrode of a positive electrode and a negative electrode of the photoelectric conversion device for pulling out an output of the conversion device from the one electrode to an outside, an electric connection portion for connecting the other electrode of the positive and negative electrodes to the conductive portion, and a second conductive member for pulling out the output from the other electrode via the electric connection portion and the conductive portion to the outside. The second conductive member is connected directly or indirectly to a position of the conductive portion.

Description

Title of Invention: PHOTOELECTRIC CONVERTER

Technical Field

[0001] The present invention relates to a low-cost and high-reliability photoelectric converter and particularly to a photoelectric converter wherein the lines from the electrodes are routed using a good conductive portion of a substrate.

Background Art

[0002] Today, intensive researches are being conducted in solar cells. Solar cell modules forming a solar cell each comprise a solar cell submodule including a number of series-connected laminate-structured photoelectric conversion elements formed on a substrate, each of which is essentially composed of a semiconductor photoelectric conversion layer generating current by light absorption sandwiched by a back electrode (bottom or lower electrode) and a transparent electrode (upper electrode). Among such solar cell submodules proposed is one, for example, as follows.

[0003] As illustrated in Fig. 10, a solar cell module 100 has a glass substrate 104 provided on the backside of a solar cell submodule 102 and a cover glass 108 secured to the opposite side from the glass substrate 104 of the solar submodule 102 by an EVA resin layer (ethylene vinyl acetate resin layer) 106 serving as bond/seal layer. On the backside of the glass substrate 104 is secured a back sheet 110 by another EVA resin layer 106.

[0004] The back sheet 110 has attached thereto a connection box 112 to which an internal wiring line from the solar cell submodule 102 is connected. The connection box 112 is equipped with a cable 114 through which the solar cell module 100 can be connected to the outside.

The solar cell submodule 102 and the glass substrate 104 with the cover glass 108 and the back sheet 110 attached are secured to a frame 118 through the intermediary of a seal material 116.

A variation of the solar cell module 100 is not provided with the glass substrate 104; still another variation thereof has a protection layer in lieu of the cover glass 108.

[0005] The solar cell module 100 is manufactured for example as illustrated in Figs 11A to 11D.

First, to be provided is the solar cell submodule 102 as illustrated in Fig. 11A comprising on the surface of a substrate a number of series-connected laminate-structure photoelectric conversion elements each formed of a semiconductor photoelectric conversion layer generating current by light absorption sandwiched by a back electrode and a transparent electrode.

Next, as illustrated in Fig. 11B, lines 120 using copper foil, for example, are provided at the electrode terminals of both end portions of the solar cell submodule 102. Then, lines 122 are provided so as to extend from the lines 120 located at both ends and fold back onto a backside 102b of the solar cell submodule 102 to reach a substantially central portion of the solar cell submodule 102. The wiring lines 122 are formed, for example, of copper ribbon.

[0006] Next, as illustrated in Fig. 11C, the EVA resin layer 106 and a cover layer 124 are provided on a top side 102a of the solar cell submodule 102, and the EVA resin layer 106 and the back sheet 110 are provided on a backside 102b of the solar cell submodule 102. The lines 122 project through holes (not shown) formed in the EVA resin layer 106 and the back sheet 110 provided on the backside. Now, these are integrated by a vacuum laminating method.

Subsequently follows trimming, then the procedure proceeding to fold back the lines 122 projecting from the back sheet 110 or taking other steps as may be required so that the lines 122 are connected, as illustrated in Fig. 11D, to the connection box 112, thereafter securing the connection box 112 to the back sheet 110 with an adhesive or other means.

[0007] There are proposed various other solar cell submodules than that described above (see Patent Documents 1 and 2).

The solar cell module described in Patent Document 1 has a solar cell disposed on a top surface protection member formed of FTFE (ethylene tetrafluoroethylene) and an adhesive resin made of EVA (ethylene vinyl acetate) superposed on each other. The solar cell is equipped with a power output terminal connected by soldering to a lead wire. Thereon is provided another adhesive resin formed of EVA and a notched steel plate as the back surface protection member.

The lead wire is led past a lateral side of the back surface protection member through the notch of the back surface protection member to reach the non-light receiving surface of the back surface protection member. The lead wire led onto the non-light receiving surface of the back surface protection member is routed into the terminal box provided on the non-light receiving surface of the back surface protection member to output generated electricity to the outside. Thus, the solar cell module described in the Patent Document 1 also has the terminal box positioned on the backside thereof.

[0008] The solar cell module described in the Patent Document 2 has an internal lead wire for delivering the electricity generated by the solar cell module to a terminal and a cable to pull out generated electricity on the outside, the lead wire and the cable being connected by soldering at a connection portion on a backside reinforcement plate. The cable is secured by resin formed into a cylinder provided on the surface of the backside reinforcement plate. This resin acts as the terminal portion in the solar cell module

described in the Patent Document 2. Thus, a constituent part acting as a terminal portion in the solar cell module described in the Patent Document 2 is also positioned on the backside thereof.

Citation List

Patent Literature

- [0009] [PATENT LITERATURE 1] JP 3972245 B
[PATENT LITERATURE 2] JP 2006-210446 A

Summary of Invention

TECHNICAL PROBLEMS

- [0010] With the conventional solar cell module 100, an electrode for pulling out the generated electricity was provided as described above by connecting metal ribbons, etc. to the terminals at both ends of the solar cell submodule 102 by soldering or other means and folding them back so that they are connected to the connection box 112, with insulation layers such as the EVA layers 106 and the back sheet 110 provided therebetween, as illustrated in Figs. 11B and 11D.

This configuration requires use of materials such as metal ribbons to provide the lines 122 connecting the terminals and the connection box 112, contributing to increased costs, as well as reduced reliability in case of corrosion of the metal ribbons due, for example, to admitted moisture.

- [0011] Further, as illustrated in Figs. 10 and 11D, the backside surface 102b of the solar cell submodule 102 needed to be covered entirely by the back sheet 110 or the like to cover the wiring lines 122, thereby increasing the costs of the solar cell module 100.

Further, because the lines 122 of the solar cell submodule 102 needed to be folded back onto the bottom side 102b as illustrated in Fig. 11B, an extra step therefor was required, which contributed to increased machining costs.

- [0012] From a viewpoint of reducing the thickness of solar cell modules, the thickness required for folding back the lines 122 and the thickness of the connection box 112 attached to the proximity of the center of the back sheet 110 combined to increase the thickness of the module and resulted in an uneven thickness thereof, reducing the value added.

With the modules described in the Patent Documents 1 and 2, the terminal box and the terminals are provided on the underside of the solar cell module, which increases the thickness of the solar cell modules and results in an uneven thickness thereof because the terminal box and the terminals project. This led to reduced value added of the modules.

When a solar cell module is thick, it is not appropriate for use as a BIPV (building integrated photovoltaic) type module, thus making it difficult to increase its value added,

and requires use of spacers in transport to compensate for the uneven thickness, increasing the transport costs and hence the overall costs of the solar cell module.

[0013] An object of the present invention is to overcome the above problems associated with the prior art and provide a high-reliability photoelectric converter having a simple wiring configuration.

Another object of the invention is to provide a photoelectric converter capable of reducing material costs and machining costs.

SOLUTION TO THE PROBLEMS

[0014] To achieve the above objects, the present invention provides a photoelectric converter comprising a metal substrate including a conductive portion acting as an electrical conductor and an electrical insulation layer formed on at least a surface of the conductive portion, a photoelectric conversion device formed on the insulation layer, a first conductive member connected to one electrode of a positive electrode and a negative electrode of the photoelectric conversion device for pulling out an output of the photoelectric conversion device from the one electrode to an outside, an electric connection portion for connecting the other electrode of the positive electrode and the negative electrode of the photoelectric conversion device to the conductive portion of the metal substrate, and a second conductive member for pulling out the output from the other electrode via the electric connection portion and the conductive portion of the metal substrate to the outside, the second conductive member being connected directly or indirectly to the conductive portion of the metal substrate so as to be electrically connected to the other electrode through the conductive portion of the metal substrate and the electric connection portion, wherein the second conductive member is connected to a position of the conductive portion of the metal substrate.

[0015] The first conductive member and the second conductive member are preferably provided close to each other.

Preferably, the metal substrate does not have the insulation layer at end portions of the conductive portion, and the other electrode is connected through the electric connection portion to the end portions of the conductive portion.

[0016] Preferably, the metal substrate is substantially rectangular, electrical conductors are provided end portions of at least two sides of the metal substrate electrically connected with the conductive portion, and the second conductive member is connected to the electrical conductors and electrically connected to the conductive portion via the electrical conductors.

Preferably, the metal substrate is substantially rectangular, end portions of at least two sides of the metal substrate are provided with regions of the conductive portion where the insulation layer is not formed, and the second conductive member is connected directly to regions of the conductive portion.

Preferably, the metal substrate is substantially rectangular, the photoelectric conversion device is provided with the positive and negative electrodes parallel to one side of the metal substrate, and the positive and negative electrodes have a length that is not less than a half of the length of the one side of the metal substrate.

[0017] Preferably, the metal substrate is substantially rectangular, the insulation layer is not formed at two opposite sides of the metal substrate, the photoelectric conversion device is provided with the positive and negative electrodes at both ends thereof, the other electrode of the positive and negative electrodes is connected to the conductive portion provided on one side of the two opposite sides through the electric connection portion, the second conductive member is connected to the conductive portion on the other side of the two opposite sides, and the other electrode of the photoelectric conversion device is electrically connected to the second conductive member through the electric connection portion and the conductive portion of the metal substrate.

[0018] Preferably, the photoelectric conversion device comprises series-connected photoelectric conversion elements, and a potential of electricity at the negative electrode or the positive electrode pulled out from the second conductive member to the outside is substantially equal to a maximum potential of all the photoelectric conversion elements in the photoelectric conversion device.

The maximum potential of all the photoelectric conversion elements in the photoelectric conversion device herein means a maximum voltage of the positive polarity in the design of the photoelectric conversion device. The maximum potential of the photoelectric conversion elements corresponds, for example, to that of the positive electrode or the negative electrode of the photoelectric conversion element positioned at the positive end or the negative end among a number of series-connected photoelectric conversion elements in the case of a solar cell module.

[0019] Preferably, the photoelectric conversion device is an integrated type comprising series-connected solar cells.

Preferably, the photoelectric conversion device comprises solar cells of a thin-film type.

Preferably, the photoelectric conversion device comprises one kind of solar cells of a thin-film type selected from the group consisting of CIS based thin-film solar cells, CIGS based thin-film solar cells, thin-film silicon based thin-film solar cells, CdTe based thin-film solar cells, III-V group based thin-film solar cells, dye-sensitized thin-film solar cells, and organic thin-film solar cells.

Preferably, the photoelectric conversion device comprises substrate type thin-film solar cells.

[0020] Preferably, the metal substrate has the insulation layer formed on both sides or one side thereof.

Preferably, the insulation layer is formed of at least one of aluminum oxide, silicon oxide, and resin.

Preferably, the metal substrate contains aluminum as a principal component.

Preferably, the metal substrate comprises a stainless steel plate or a steel plate.

Preferably, the metal substrate comprises a stainless steel plate or a steel plate of the metal substrate having at least its top surface covered with aluminum.

Preferably, the insulation layer is formed of anodized aluminum.

Advantageous Effects of Invention

[0021] According to the photoelectric converter of the invention, a conductive portion of the metal substrate can be used to conduct electricity and, when pulling out the output from the positive electrode or negative electrode, the line from one of the positive electrode and the negative electrode need not be extended by a long length so that wiring configuration can be simplified. Therefore, the length of the whole wiring for the photoelectric converter can be shortened. Thus, the material costs for wiring can be reduced. Further, the costs for machining, etc. can also be reduced.

[0022] According to the photoelectric converter of the invention, moreover, the connection box for connecting the photoelectric converter and the outside can be positioned at an end of the photoelectric converter, so that the thickness can be reduced and evened out, resulting in increased value added and reliability.

Brief Description of Drawings

[0023] [fig.1]Fig. 1 is a cross section schematically illustrating a solar cell submodule that is a first embodiment of the photoelectric converter according to the invention.

[fig.2]Fig. 2 is a cross section schematically illustrating a solar cell submodule that is a second embodiment of the photoelectric converter according to the invention.

[fig.3]Fig. 3 is a cross section schematically illustrating a solar cell submodule that is a third embodiment of the photoelectric converter according to the invention.

[fig.4]Fig. 4 is a cross section schematically illustrating a solar cell submodule that is a fourth embodiment of the photoelectric converter according to the invention.

[fig.5]Fig. 5 is a cross section schematically illustrating a solar cell submodule that is a fifth embodiment of the photoelectric converter according to the invention.

[fig.6A]Fig. 6A is a cross section schematically illustrating a solar cell submodule that is a sixth embodiment of the photoelectric converter according to the invention;

[fig.6B]Fig. 6B is a top plan view schematically illustrating a solar cell submodule, the sixth embodiment of the photoelectric converter according to the invention.

[fig.7]Fig. 7 is a cross section schematically illustrating a solar cell submodule that is a seventh embodiment of the photoelectric converter according to the invention.

[fig.8]Fig. 8 is a cross section schematically illustrating a solar cell submodule that is a

eighth embodiment of the photoelectric converter according to the invention.

[fig.9]Fig. 9 is a cross section schematically illustrating a solar cell submodule that is a ninth embodiment of the photoelectric converter according to the invention.

[fig.10]Fig. 10 is a schematic cross section illustrating a conventional solar cell module.

[fig.11]Figs. 11A to 11D are schematic views illustrating the steps of a method of manufacturing a conventional solar cell module in sequential order as they are taken.

Description of Embodiments

[0024] The photoelectric converter of the invention will be described below based on the embodiments illustrated in the attached drawings.

Fig. 1 is a cross section schematically illustrating a solar cell submodule that is a first embodiment of the photoelectric converter according to the invention.

This embodiment will be described by way of a solar cell submodule as a representative example of the photoelectric converter. Note that the photoelectric converter is not limited to solar cell submodules.

[0025] As illustrated in Fig. 1, a solar cell submodule 10 according to the first embodiment of the invention comprises a substantially rectangular metal substrate 12, for example. The metal substrate 12 has a core material made of a stainless steel plate (which corresponds to a conductive portion in the invention) 14 provided with aluminum layers (which correspond to conductive portions in the invention) 16, 17 on its top surface 14a and back surface 14b, respectively. Thus, the top and backsides of the metal substrate 12 have surfaces formed of the aluminum layers 16, 17, respectively.

The aluminum layers 16, 17 of the metal substrate 12 are provided respectively with insulation layers 18, 19, so that the metal substrate 12 has the insulation layers 18, 19 on both sides thereof. The insulation layer 18 is not formed at either of end portions 16a, 16b of the aluminum layer 16 provided on the top side. The insulation layer 19 is also not formed on either of end portions 17a, 17b of the aluminum layer 17 provided on the backside.

[0026] Such regions without the insulation layers 18, 19 may be secured by first forming the insulation layers 18, 19, and subsequently removing the applicable portions of the insulation layers 18, 19 by, say, laser scribing.

Alternatively, where the insulation layers 18, 19 are formed by anodization, the regions without the insulation layers 18, 19 may be secured by masking both end portions and the lateral portions of the metal substrate 12.

On a surface 18a of the insulation layer 18 are formed, for example, photoelectric conversion elements (which correspond to the solar cells of the invention) 30 according to this embodiment, as will be described. The series-connected photoelectric

conversion elements 30 form a so-called integrated type photoelectric conversion device 31.

[0027] The solar cell module 10 illustrated in Fig. 1 is of a substrate type, wherein the photoelectric conversion elements 30 provided in the solar cell submodule 10 as will be described are of a thin film type. The solar cell submodule 10 has thereon provided back electrodes 20, 20a, photoelectric conversion layers 22, buffer layers 24, and transparent electrodes 26 superposed on each other in this order; the back electrodes 20, 20a, the photoelectric conversion layers 22, the buffer layers 24, and the transparent electrodes 26 form the photoelectric conversion elements 30.

The back electrodes 20, 20a share the same configuration except for their location and, hence, will not be distinguished from each other in the description to follow, simply using an expression "back electrodes 20" unless otherwise expressly described.

[0028] The back electrodes 20 are formed on the surface 18a of the insulation layer 18 so as to share a separation groove (P1) 23 with adjacent back electrodes 20. The photoelectric conversion layers 22 are formed on the back electrodes 20 so as to fill the separation grooves (P1) 23. The buffer layers 24 are formed on the surfaces of the photoelectric conversion layers 22. The photoelectric conversion layers 22 and the buffer layers 24 are separated from an adjacent photoelectric conversion layer 22 and an adjacent buffer layer 24 by grooves (P2) 25 reaching the back electrodes 20. The grooves (P2) 25 are formed in different positions from those of the separation grooves (P1) 23 separating the back electrodes 20.

[0029] The transparent electrodes 26 are formed on the surfaces of the buffer layers 24 so as to fill the grooves (P2) 25.

Opening grooves (P3) 27 are formed so as to reach the back electrodes 20 through the transparent electrodes 26, the buffer layers 24, and the photoelectric conversion layers 22. The photoelectric conversion elements 30 are connected in series to each other through the back electrodes 20 and the transparent electrodes 26. In this embodiment, the back electrode 21 disposed at the left end portion as seen in Fig. 1 is connected to the end portion 16b without the insulation layer 18 and thus electrically connected to the metal substrate 12. The back electrode 21 corresponds to the electric connection portion in the invention.

[0030] The photoelectric conversion elements 30 of this embodiment are so-called integrated type CIGS photoelectric conversion elements (CIGS solar cells) and have a configuration such, for example, that the back electrodes 20 are molybdenum electrodes, the photoelectric conversion layers 22 are formed of CIGS, the buffer layers 24 are formed of CdS, and the transparent electrodes 26 are formed of ZnO.

Although not shown in the drawing, the photoelectric conversion elements 30 are parallel to a side of the metal substrate 12 and longer in that direction. Accordingly, the

back electrode 21, for example, is also longer in the direction parallel to the one side of the metal substrate 12.

[0031] As illustrated in Fig. 1, a first conductive member 32 is connected to a surface 26a of the transparent electrode 26 of the photoelectric conversion element 30 that is disposed on the right-most back electrode 20a. The first conductive member 32 is provided to pull out the output from a negative electrode as will be described.

The first conductive member 32 is a long strip connected to the metal substrate 12 and extending in the direction parallel to the side thereof. The first conductive member 32 is formed, for example, of a copper ribbon 32a covered with a coating material 32b made of an alloy of indium and copper. The first conductive member 32 is connected to the surface 26a of the transparent electrode 26 of the photoelectric conversion element 30 by, for example, an ultrasonic solder.

[0032] A second conductive member 34 is connected to the end portion 16a without the insulation layer 18 and thus electrically connected to the metal substrate 12. The second conductive member 34 is connected to the back electrode 21 and the metal substrate 12 (the aluminum layer 16 and the stainless steel plate 14) acting as a conductor. The second conductive member 34 is provided to pull out the output from the positive electrode as will be described. Like the first conductive member 32, the second conductive member 34 is a long strip connected to the metal substrate 12 and extending in a direction parallel to said side thereof. The first conductive member 32 and the second conductive member 34 are disposed adjacent to and parallel to each other (see Fig. 6B).

[0033] The second conductive member 34 is composed similarly to the first conductive member 32 and formed, for example, of a copper ribbon 34a covered with a coating material 34b made of a copper indium alloy.

The first conductive member 32 and the second conductive layer 34 may be formed of a tin-coated copper ribbon. Further, the first conductive member 32 and the second conductive member 34 may be secured by such means as, for example, a conductive adhesive and conductive tape in lieu of by an ultrasonic solder.

[0034] The photoelectric conversion elements 30 of this embodiment may be fabricated by any of known methods used to fabricate CIGS solar cells. The separation grooves (P1) 23 of the back electrodes 20, the grooves (P2) 25 reaching the back electrodes 20, and the opening grooves (P3) 27 reaching the back electrodes 20 may be formed by laser scribing or mechanical scribing.

[0035] Light entering the photoelectric conversion elements 30 from the side bearing the transparent electrodes 26 passes through the transparent electrodes 26 and the buffer layers 24 and causes the photoelectric conversion layers 22 to generate electromotive force, thus producing a current flowing, for example, from the transparent electrodes

26 to the back electrodes 20. Note that the arrows shown in Fig. 1 indicate the direction of the current, and the direction in which electrons move is opposite to that of the current. Accordingly, the leftmost back electrode 21 in Fig. 1 has the positive polarity (plus polarity) and the rightmost back electrode 20 has the negative polarity (minus polarity).

[0036] According to this embodiment, the back electrode 21 is connected to the aluminum layer 16 of the metal substrate 12, and the second conductive member 34 is connected to the aluminum layer 16 of the metal substrate 12. Thus, the back electrode 21 and the second conductive member 34 are electrically connected through the aluminum layer 16 and the stainless steel plate 14 of the metal substrate 12 acting as conductor. The first conductive member 32 is connected to a transparent electrode 26. Thus, the electricity generated by the solar cell submodule 10 can be pulled out from the solar cell submodule 10 through the first conductive member 32 and the second conductive member 34 adjacent to each other. The first conductive member 32 has a negative polarity; the second conductive member 34 has a positive polarity. The polarities of the first conductive member 32 and the second conductive layer 34 may be reversed; their polarities vary according to the configuration of the photoelectric conversion elements 30, the configuration of the solar cell submodule 10, and the like.

The top side of the solar cell submodule 10 denotes the side for receiving light for obtaining electricity; the backside denotes the opposite side from the top side.

[0037] According to this embodiment, the second conductive member 34 is connected through the metal substrate 12 to the photoelectric conversion element 30 positioned at the positive end of the series-connected photoelectric conversion elements 30. Therefore, the second conductive member 34 is connected to the photoelectric conversion element 30 having a highest potential of all the photoelectric conversion elements 30 in the photoelectric conversion device 31. Thus, the electricity pulled out from the second conductive member 34 has the highest potential.

[0038] In this embodiment, the metal substrate 12, e.g., the aluminum layer 16 and the stainless steel plate 14, is used as a conductor. The metal substrate 12, although a clad substrate formed of the stainless steel plate 14 and the aluminum layers 16, 17, does not consume the current generated by the solar cell submodule 10 by virtue of sufficiently high conductivities of both the stainless steel plate 14 and the aluminum layers 16, 17.

[0039] According to this embodiment, the electricity generated by the solar cell submodule 10 can be pulled out as described above from the first conductive member 32 and the second conductive member 34 positioned adjacent to each other. This configuration eliminates the need to fold the lines at the terminals provided at both ends of the solar cell submodule back to the center thereof as was the case with the prior art. This also

provides an advantage of a reduced length of the wiring. Thus, the wiring can be simplified. Hence, the material costs for wiring can be reduced. In addition, work performed for wiring can also be saved, resulting in reduction of machining costs, costs for installing the solar cell modules, and the like.

[0040] Further, this embodiment permits improvements on the product quality and reliability of a solar cell module comprising the solar cell submodule by virtue of its simplified wiring. Further, since the first conductive member 32 and the second conductive member 34 are located close to each other, routing the lines therefrom can be simplified such that the connection box of the solar cell module can be positioned close to a corner of the solar cell module in lieu of at the center thereof as was the case with the prior art. Thus, the aesthetic appearance can also be improved, increasing the value added of the solar cell module.

Since the connection box can be thus positioned close to a corner of the solar cell module, the solar cell module can be made thinner, or a higher value added can be achieved by virtue of a uniform thickness attained, and installation work can be improved and reliability enhanced by virtue of a thinner design and a uniform thickness achieved.

[0041] The solar cell submodule 10 according to this embodiment illustrated in Fig. 1 may be formed into a solar cell module for example as follows.

The top side of the solar cell submodule 10 is provided with a bond/seal layer, a water vapor barrier layer (protection layer), and a top surface protection layer (protection layer); the backside of the solar cell module 10 is provided with a bond/seal layer and a back sheet (protection layer). These layers are integrated with the solar cell submodule 10 by vacuum laminating method to obtain a solar cell module.

The back sheet has holes previously formed therein so that the first conductive member 32 and the second conductive member 34 protrude from the back sheet to permit connection with the connection box provided to pull out from the solar cell module the electricity it has generated.

The connection box is connected to a power cable or the like, which is bonded and sealed to the surface of the back sheet by, for example, a silicon resin.

[0042] The bond/seal layer is provided to seal and protect the solar cell submodule 10 and bond it to the water vapor barrier layer.

The bond/seal layer is formed, for example, of EVA (ethylene vinyl acetate) or PVB (Polyvinylbutyral).

[0043] The water vapor barrier layer is provided to protect the solar cell submodule 10 from moisture. The water vapor barrier layer is formed of a transparent film made of, for example, PET or PEN, having an inorganic layer of, for example, SiO_2 or SiN formed thereon. The water vapor barrier layer is formed of an inorganic layer made of, for

example, SiO₂ or SiN sandwiched by transparent films made of, for example, PET or PEN.

The water vapor barrier layer is not specifically limited in composition, provided that it meets given performance requirements such as moisture vapor transmission rate, oxygen transmission rate, etc.

[0044] The top surface protection layer is provided to protect the solar cell submodule 10 from stain or smear and minimize the decrease of incoming light into the solar cell submodule 10 due to smear or stain. The top surface protection layer is formed, for example, of a fluorinated resin film. The fluorinated resin used is, for example, EFTE (ethylene/tetrafluoroethylene copolymer). The top surface protection layer has a thickness of say 20 micrometers to 200 micrometers.

[0045] The bond/seal layer provided on the backside of the solar cell submodule 10 has the same composition as that provided on the top side and will not be described in detail.

The back sheet is provided to protect the solar cell submodule 10 from the backside. The back sheet 22 has a structure such that an aluminum foil is sandwiched by resin films of PET, PEN, or the like. The back sheet is not specifically limited in composition.

[0046] As described above, the metal substrate 12 used in this embodiment is a clad substrate formed of the stainless steel plate 14 as a core material and the aluminum layers 16, 17 as coating layers. The composition of the stainless steel plate 14 may be determined as appropriate from the results of a stress calculation based on material properties of the insulation layer and the photoelectric conversion elements used. The stainless steel plate 14 may be formed, for example, of austenitic stainless steel (thermal expansion coefficient: $17 \times 10^{-6}/\text{deg C}$), carbon steel or ferritic stainless steel ($10 \times 10^{-6}/\text{deg C}$) to control the thermal expansion coefficient of the photoelectric conversion elements as a whole.

The metal substrate 12 may use a plate member formed, for example, of steel such as mild steel, 42 invar alloy, kovar alloy ($5 \times 10^{-6}/\text{deg C}$) or 36 invar alloy ($< 1 \times 10^{-6}/\text{deg C}$) in lieu of the stainless steel plate 14.

[0047] The stainless steel plate 14 may have any thickness as appropriate according to the ease of handling in the manufacture of photoelectric conversion elements and in use (strength and flexibility); the thickness is preferably in a range of 10 micrometers to 1 mm.

[0048] The stiffness of the stainless steel plate 14, of which the elastic limit stress without plastic deformation is of critical importance, is defined in terms of yield stress or 0.2% proof stress. The 0.2% proof stress and the temperature dependency of the 0.2% proof stress of the stainless steel plate 14 is described in "Steel Material Handbook" edited by the Japan Institute of Metals and the Iron and the Steel Institute of Japan, published

by Maruzen Company, Limited or in "Stainless Steel Handbook (3rd edition)," edited by the Japan Stainless Steel Association and published by Nikkan Kogyo Shimbun. The 0.2% proof stress of the stainless steel plate 14, although dependent upon the degree of machining and thermal refining, is preferably 250 MPa to 900 MPa at room temperature. Although the photoelectric conversion elements (photoelectric conversion device) of the photoelectric converter reach a high temperature of 500 deg C or higher at the time of manufacture, generally about 70 % of the proof stress of the steel is maintained at 500 deg C. Although dependent upon the degree of machining and thermal refining, the proof stress of aluminum at room temperature is 300 MPa or more but decreases to 1/10 or lower at a temperature of 350 deg C or higher. Accordingly, the elastic limit stress and the thermal expansion of the metal substrate 12 at a high temperature mostly depend upon the high temperature characteristics of the stainless steel plate 14. The Young's moduli of aluminum and stainless steel and their temperature dependencies needed for stress calculation are described in "Elastic Moduli of Metallic Materials" by The Japan Society of Mechanical Engineers.

[0049] The aluminum layers 16, 17 may be formed using, for example, an alloy of a Class 1000 pure aluminum as defined by Japan Industrial Standard (JIS), an Al-Mn alloy, an Al-Mg alloy, an Al-Mn-Mg alloy, an Al-Zr alloy, an Al-Si alloy, or an Al-Mg-Si alloy and another metallic element (see "Aluminum Handbook, 4th edition)" (published in 1990 by Japan Light Metal Association). The aluminum layers 16, 17 may contain a trace amount of a metallic element such as Fe, Si, Mn, Cu, Mg, Cr, Zn, Bi, Ni, and Ti.

[0050] The thicknesses of the aluminum layers 16, 17 may be determined as appropriate according to the results of stress calculations based upon the whole layer configuration and the material properties of the photoelectric converter. When integrated with the metal substrate 12, the aluminum layers 16, 17 have thicknesses of 0.1 micrometers to 500 micrometers. Interposition of the aluminum layers 16, 17 between the stainless steel plate 14 and the insulation layers 18, 19 formed of the anodized film moderates a stress that may act upon the insulation layers 18, 19 upon thermal expansion due to temperature variation. When forming the insulation layers 18, 19 on the metal substrate 12, the thicknesses of the aluminum layers 16, 17 decrease as they undergo anodization, washing prior to anodization, and polishing. Therefore, the thicknesses of the aluminum layers 16, 17 need to allow for such reduction in thickness.

[0051] The aluminum layers 16, 17 may be formed by any method as appropriate, provided that adhesion between the stainless steel plate 14 and the aluminum layers 16, 17 are ensured. The aluminum layers 16, 17 may be formed on the stainless steel plate 14 by, for example, vapor phase deposition methods such as vapor deposition, sputtering, etc., hot dip metal coating by immersion in a molten aluminum bath, a bonding method such as pressure bonding by rolling after surface cleaning, and any other method as ap-

appropriate.

When using hot dip metal coating, caution should be used not to admit fragile inter-metallic compounds at the interface between the stainless steel plate 14 and the aluminum layers 16, 17. From a viewpoint of manufacturing costs and productivity, the aluminum layers 16, 17 are preferably formed by pressure bonding by rolling or other means.

[0052] The insulation layers 18, 19 typically are anodized films having fine pores produced by anodization of the aluminum layers 16, 17. These anodized films have an enhanced insulation performance.

[0053] Anodization is achieved by immersing the metal substrate 12 as the positive electrode in an electrolytic solution together with the negative electrode and applying a voltage between the positive and negative electrodes. Where necessary, the anodization may include steps of subjecting the aluminum layers 16, 17 to washing and polishing and smoothing processes. The negative electrode is typically formed of carbon, aluminum, or the like. The electrolyte is not specifically limited; preferably used is one or more kinds of acids selected from sulfuric acid, phosphoric acid, chromic acid, oxalic acid, sulfamic acid, benzenesulfonic acid, and amidosulfonic acid to prepare an acidic electrolytic solution. The anodizing conditions vary with the kinds of electrolytes used and are not specifically limited. By way of example, the conditions may include an electrolyte concentration of 1 mass% to 80 mass%, a liquid temperature of 5 deg C to 70 deg C, a current density of 0.005 A/cm² to 0.60 A/cm², a voltage of 1 V to 200 V, and an electrolysis time of 3 min to 500 min. The electrolytic solution preferably contains a sulfuric acid, phosphoric acid, or oxalic acid or mixture thereof. Electrolytes as described above are used preferably with an electrolyte concentration of 4 mass% to 30 mass%, a current density of 0.05 A/cm² to 0.30 A/cm², and a voltage of 30 V to 150 V.

[0054] In anodization of the aluminum layers 16, 17, oxidation reaction takes place from the surfaces and substantially vertically to produce anodized films. Where any of the above electrolytic solution is used, the anodized films obtained will have a number of fine columns tightly arranged having a substantially hexagonal form as seen in planar view. The fine columns each have a pore at the core, the bottom being somewhat rounded. At the bottom of the fine columns is formed a barrier layer with a thickness of 0.02 micrometers to 0.1 micrometers is formed. In lieu of the acidic electrolytic solution, a neutral electrolytic solution such as one containing boric acid, etc. may be used for electrolytic treatment, whereby anodized films having a denser composition can be obtained in place of those where the porous fine columns are arranged. After producing the porous anodized films using an acidic electrolytic solution, pore filling technique may be used to perform additional electrolytic treatment in order to increase

the thickness of the barrier layer.

- [0055] The thicknesses of the insulation layers 18, 19 are not specifically limited, provided that the insulation layer 14 has insulation properties and a surface hardness sufficient to prevent damage that may be caused by a mechanical impact during handling. An excessive thickness thereof, however, may present problems from a viewpoint of flexibility. Accordingly, a preferred thickness of the insulation layers 18, 19 is 0.5 micrometers to 50 micrometers; the thickness can be controlled using the electrolysis time in constant current electrolysis as well as constant voltage electrolysis.

Where the insulation layers 18, 19 are formed by anodization technique, the lateral sides of the metal substrate 12 (stainless steel plate 14) need to be masked for insulation to prevent formation of a local battery between the stainless steel plate 14 and the aluminum layers 16, 17. Where an anodized film is formed on one of the aluminum layers 16, 17, the surface of the other of the aluminum layers 16, 17 needs to be masked for insulation in addition to the lateral sides of the metal substrate 12 (stainless steel plate 14).

- [0056] The insulation layers 18, 19 are not limited to aluminum oxide layers produced by anodization. The insulation layers 18, 19 are exemplified by aluminum oxide films, silicon oxide films, and resin layers containing a polymer. The insulation layers 18, 19 may be formed, for example, by a CVD method, a PVD method, or a sol-gel method; the thicknesses are in a range of 1 micrometers to 100 micrometers, preferably 10 micrometers to 50 micrometers.

- [0057] Resins for forming the resin layer containing a polymer may be polyimide or vinylidene chloride, for example. The resin layer containing a polymer may be formed by any of the known coating methods and dispensing methods including knife coating, roller coating, and brush coating.

Where, for example, polyimide is used as resin for forming the resin layer, a solution of polyamide, used as a coating agent, is dried upon coating and then heated for imidization, thereby forming an insulation layer.

- [0058] The back electrodes 20 and the transparent electrodes 26 of the photoelectric conversion elements 30 are provided both to pull out current generated by the photoelectric conversion layers 22. Both the back electrodes 20 and the transparent electrodes 26 are each made of a conductive material. The transparent electrodes 26, provided on the side from which light is admitted, need to be pervious to light.

- [0059] The back electrodes 20 are formed, for example, of Mo, Cr or W, or a material composed of two or more of these. The back electrodes 20 may have a single-layer structure or a laminated structure such as a dual-layer structure.

Preferably, the back electrodes 20 have a thickness of 100 nm or more, more preferably 0.45 micrometers to 1.0 micrometers.

The back electrodes 20 may be formed by any of vapor phase deposition methods as appropriate such as electron beam deposition and sputtering.

- [0060] The transparent electrodes 26 are formed, for example, of ZnO added with Al, B, Ga, Sb, etc., ITO (indium tin oxide), SnO_2 , or a material composed of two or more of these. The transparent electrodes 26 may have a single-layer structure or a laminated structure such as a dual-layer structure. The thickness of the transparent electrodes 26, not specifically limited, is preferably 0.3 micrometers to 1 micrometer.

The transparent electrodes 26 may be formed by any of vapor phase deposition methods as appropriate such as electron beam deposition and sputtering.

- [0061] The buffer layers 24 are provided to protect the photoelectric conversion layers 22 when forming the transparent electrodes 26 and admit the light entering the transparent electrodes 26 into the photoelectric conversion layers 22.

The buffer layers 24 are formed, for example, of CdS, ZnS, ZnO, ZnMgO, or ZnS (O, OH) or a material composed of two or more of these.

The buffer layers 24 preferably have a thickness of 0.03 micrometers to 0.1 micrometers. The buffer layers 24 are formed, for example, by the chemical bath deposition (CBD) method.

- [0062] The photoelectric conversion layers 22 absorb the incoming light admitted through the transparent electrodes 26 and the buffer layers 24 to generate current. According to this embodiment, the photoelectric conversion layers 22 are not specifically limited in configuration; they may be formed, for example, of a compound semiconductor having at least one kind of chalcopyrite structure. The photoelectric conversion layers 22 may be formed of at least one kind of compound semiconductor composed of a Ib group element, a IIIb group element, and a VIb group element.

- [0063] For a high optical absorptance and a high photoelectric conversion efficiency, the photoelectric conversion layers 22 are preferably formed of at least one kind of compound semiconductor composed of at least one kind of Ib group element selected from the group consisting of Cu and Ag, at least one kind of IIIb group element selected from the group consisting of Al, Ga, and In, and at least one kind of VIb group element selected from the group consisting of S, Se, and Te. The compound semiconductor is exemplified by CuAlS_2 , CuGaS_2 , CuInS_2 , CuAlSe_2 , CuGaSe_2 , CuInSe_2 (CIS), AgAlS_2 , AgGaS_2 , AgInS_2 , AgAlSe_2 , AgGaSe_2 , AgInSe_2 , AgAlTe_2 , AgGaTe_2 , AgInTe_2 , $\text{Cu}(\text{In}_{1-x}\text{Ga}_x)\text{Se}_2$ (CIGS), $\text{Cu}(\text{In}_{1-x}\text{Al}_x)\text{Se}_2$, $\text{Cu}(\text{In}_{1-x}\text{Ga}_x)(\text{S}, \text{Se})_2$, $\text{Ag}(\text{In}_{1-x}\text{Ga}_x)\text{Se}_2$, and $\text{Ag}(\text{In}_{1-x}\text{Ga}_x)(\text{S}, \text{Se})_2$.

- [0064] The photoelectric conversion layers 22 preferably contain CuInSe_2 (CIS) and/or $\text{Cu}(\text{In}, \text{Ga})\text{Se}_2$ (CIGS), which is obtained by dissolving Ga in the former. CIS and CIGS are semiconductors each having a chalcopyrite crystal structure and reportedly have a high optical absorptance and a high photoelectric conversion efficiency. Further, CIS

and CIGS have an excellent durability such that they are less liable to decrease in efficiency through exposure to light or other causes.

[0065] The photoelectric conversion layers 22 contain impurities for obtaining a desired semiconductor conductivity type. Impurities may be added to the photoelectric conversion layers 22 by diffusion from adjacent layers and/or direct doping. The photoelectric conversion layers 22 permit presence therein of a component element of I-III-VI group semiconductor and/or a density distribution of impurities; the photoelectric conversion layers 26 may contain a plurality of layer regions formed of materials having different semiconductor properties such as n-type, p-type, and i-type.

For example, a CIGS semiconductor, when given a thickness-wise distribution of Ga amount in the photoelectric conversion layers 22, permits control of band gap width, carrier mobility, etc. and thus achieves a high photoelectric conversion efficiency.

[0066] The photoelectric conversion layers 22 may contain one or two or more kinds of semiconductors other than I-III-VI group semiconductors. Such semiconductors other than I-III-VI group semiconductors include a semiconductor formed of a IVb group element such as Si (IV group semiconductor), a semiconductor formed of a IIb group element and a Vb group element (III-V group semiconductor) such as GaAs, and a semiconductor formed of a IIb group element and a VIb group element (II-VI group semiconductor) such as CdTe. The photoelectric conversion layers 22 may contain any other component than a semiconductor and impurities used to obtain a desired conductivity type, provided that no detrimental effects are thereby produced on the properties.

The photoelectric conversion layers 22 may contain a I-III-VI group semiconductor in any amount as deemed appropriate. The ratio of a I-III-VI group semiconductor contained in the photoelectric conversion layers 22 is preferably 75 mass% or more and, more preferably, 95 mass% or more and, most preferably, 99 mass% or more.

[0067] When the photoelectric conversion layers 22 of this embodiment are CIGS layers, the CIGS layers may be formed by such known deposition methods as 1) multi-source co-evaporation methods, 2) selenization method, 3) sputtering method, 4) hybrid sputtering method, and 5) mechanochemical processing method.

[0068] 1) Known multi-source co-evaporation methods include:
three-stage method (J.R. Tuttle et al, Mat. Res. Soc. Symp. Proc., Vol. 426 (1966), p. 143, etc.) and a simultaneous evaporation method by EC group (L. Stolt et al.: Proc. 13th ECPVSEC (1995, Nice) 1451, etc.).

According to the first-mentioned three-phase method, firstly, In, Ga, and Se are simultaneously evaporated under high vacuum at a substrate temperature of 300 deg C, which is then increased to 500 deg C to 560 deg C to simultaneously vapor-deposit Cu and Se, whereupon In, Ga, and Se are simultaneously evaporated. According to the

latter method or the simultaneous evaporation method by EC group, Cu excess CIGS is vapor-deposited in an earlier stage of vapor deposition, and In excess CIGS is vapor-deposited in a later stage.

[0069] Following methods are among those where improvements have been made on the above methods to improve crystallinity of CIGS films.

a) Method using ionized Ga (H. Miyazaki et al, phys. stat. sol. (a), Vol. 203 (2006), p. 2603, etc.)

b) Method using radicalized Se (a pre-printed collection of speeches given at the 68th Academic Lecture by Japan Society of Applied Physics) (autumn of 2007, Hokkaido Kogyo Univ.), 7P-L-6, etc.)

c) Method using cracked Se (a pre-printed collection of speeches given at the 54th Academic Lecture by Japan Society of Applied Physics) (spring of 2007, Aoyama Gakuin Univ.), 29P-ZW-14, etc.), and

d) Method using light excitation process (a pre-printed collection of speeches given at the 54th Academic Lecture by Japan Society of Applied Physics) (spring of 2007, Aoyama Gakuin Univ.), 29P-ZW-14, etc.).

[0070] 2) The selenization method is also called two-stage method, whereby firstly a metal precursor formed of a laminated film such as a Cu layer/In layer, a (Cu-Ga) layer/In layer, or the like is formed by sputter deposition, vapor deposition, or electrodeposition, and the film thus formed is heated in selenium vapor or hydrogen selenide to a temperature of 450 deg C to 550 deg C to produce a selenide such as $\text{Cu}(\text{In}_{1-x}\text{Ga}_x)\text{Se}_2$ by thermal diffusion reaction. This method is called vapor-phase selenization method. Another method available for the purpose is the solid-phase selenization method whereby solid-phase selenium is disposed on a metal precursor film to achieve selenization by solid-phase diffusion reaction using the solid-phase selenium as selenium source.

[0071] The selenization method may be implemented in several ways: selenium is previously mixed in a given ratio into the metal precursor film to avoid abrupt volume expansion that might take place in selenization process (T. Nakada et al, Solar Energy Materials and Solar Cells 35 (1994) 204-214, etc.); or selenium is sandwiched between thin metal films (e.g., as in Cu layer/In layer/Se layer ... Cu layer/In layer/Se layer) to form a multiple-layer precursor film (T. Nakada et al, Proc. of 10th European Photovoltaic Solar Energy Conference (1991) 887 - 890, etc.).

[0072] Among the methods of forming a graded band gap CIGS film is one whereby firstly a Cu-Ga alloy film is disposed, and an In film is disposed thereon, subsequently achieving selenization by inclining the Ga density in the film thickness direction using natural thermal diffusion (K. Kushiya et al, Tech Digest 9th Photovoltaic Science and Engineering Conf. Miyazaki, 1996 (Intn. PVSEC-9, Tokyo, 1996) p. 149, etc.)

- [0073] 3) Known sputter deposition techniques include:
 one using CuInSe₂ polycrystal as a target, one called two-source sputter deposition using Cu₂Se and In₂Se₃ as targets and using H₂Se/Ar mixed gas as sputter gas (J. H. Ermer, et al, Proc. 18th IEEE Photovoltaic Specialists Conf. (1985) 1655 - 1658, etc.) and
 one called three-source sputter deposition whereby a Cu target, an In target, and an Se or CuSe target are sputtered in Ar gas (T. Nakada, et al, Jpn. J. Appl. Phys. 32 (1993) L1169 - L1172, etc.).
- [0074] 4) Known hybrid sputter deposition methods include one whereby metals Cu and In are subjected to direct current sputtering, while only Se is vapor-deposited (T. Nakada, et al., Jpn. Appl. Phys. 34 (1995) 4715 - 4721, etc.).
- [0075] 5) The mechanochemical processing method is a method whereby a material selected according to the CIGS composition is placed in a planetary ball mill container and mixed by mechanical energy to obtain pulverized CIGS, which is then applied to a substrate by screen printing and annealed to obtain a CIGS film (T. Wada et al, Phys. stat. sol. (a), Vol. 203 (2006) p. 2593, etc.).
- [0076] Other methods of forming a CIGS film include screen printing method, close-spaced sublimation method, MOCVD method, and spray method. For example, the screen printing method or the spray method may be used to form a fine-particle film containing a Ib group element, a IIIb group element, and a VI group element on a substrate and obtain a crystal having a desired composition by, for example, pyrolysis treatment (which may be a pyrolysis treatment carried out under a VIb group element atmosphere) (JP 9-74065 A, JP 9-74213 A, etc.).
- [0077] Next, a second embodiment of the invention will be described.
 Fig. 2 is a cross section schematically illustrating a solar cell submodule that is a second embodiment of the photoelectric converter according to the invention.
 The same components of this embodiment as those of the solar cell submodule 10 according to the first embodiment illustrated in Fig. 1 are given like reference characters, and a detailed description thereof will be omitted.
- [0078] As illustrated in Fig. 2, a solar cell submodule 10a has a metal substrate 12a that is different from that of the solar submodule 10 (see Fig. 1) according to the first embodiment; the other components and configuration are similar to those of the solar submodule 10 (see Fig. 1) according to the first embodiment, and their description will be omitted.
- [0079] The solar submodule 10a according to the first embodiment illustrated in Fig. 2 has a metal substrate 12a of which not only the top surface 14a and back surface 14b but the lateral sides 14c are also covered with an aluminum layer 36. In other words, the whole surface of the stainless steel plate 14 is covered with the aluminum layer 36. The

aluminum layer 36 may have the same configuration as the aluminum layer 16 of the first embodiment. Therefore, a detailed description of the aluminum layer 36 will be omitted.

[0080] According to this embodiment, the insulation layer 18 is provided in a region corresponding to the top surface 14a of the stainless steel plate 14; the insulation layer 19 is provided in a region corresponding to the back surface 14b of the stainless steel plate 14.

As with the first embodiment, the insulation layer 18 of the metal substrate 12a is not provided at either of end portions 36a, 36b of the aluminum layer 36 on the top surface 14a of the stainless steel plate 14. Likewise, the insulation layer 19 is also not formed on either of the end portions 36c, 36d on the back surface 14b of the stainless steel plate 14.

The second conductive member 34 is provided on the one end portion 36a of the aluminum layer 36, where the insulation layer 18 is not provided, on the top surface 14a of the stainless steel plate 14. The back electrode 21 is connected to the other end portion 36b, where the insulation layer is not provided.

[0081] According to this embodiment, wherein the whole surface of the stainless steel plate 14 is coated with the aluminum layer 36 as illustrated in Fig. 2, an electrolytic solution used for anodization to form the anodized films as the insulation layers 18, 19 do not come into contact with the stainless steel plate 14 unlike in the first embodiment. Thus, the electrolytic solution and the stainless steel plate 14 do not react. Further, since the electrolytic solution and the stainless steel plate 14 do not contact, there is no need to increase the current in the anodization process.

According to this embodiment, the metal substrate 12a is formed, for example, by immersing the stainless steel plate 14 in a molten metal bath having a composition of the aluminum layer 36 to coat the stainless steel plate 14 with the molten metal so that the aluminum layer 36 is formed over the whole surface of the stainless steel plate 14.

[0082] Different from the first embodiment only in the configuration of the metal substrate 12a, this embodiment produces the same effects as the first embodiment, although a detailed description thereof will be omitted.

[0083] Next, a third embodiment of the invention will be described.

Fig. 3 is a cross section schematically illustrating a solar cell submodule that is a third embodiment of the photoelectric converter according to the invention.

The same components of this embodiment as those of the solar cell submodule 10 according to the first embodiment illustrated in Fig. 1 are given like reference characters, and a detailed description thereof will be omitted.

[0084] As illustrated in Fig. 3, a solar cell submodule 10b has a metal substrate 12b that is different from its counterpart of the solar submodule 10 (see Fig. 1) according to the

first embodiment; the other components and configuration are similar to those of the solar submodule 10 (see Fig. 1) according to the first embodiment, and their description will be omitted.

[0085] In the solar submodule 10b according to this embodiment illustrated in Fig. 3, the metal substrate 12b has the aluminum layer 16 provided only on one side, i.e., the top surface 14a, of the stainless steel plate 16, on which the insulation layer 18 is provided.

According to this embodiment, for example, the regions of the aluminum layer 16 other than where the insulation 18 is to be formed are masked before anodization to form the insulation layer 18 only on one side of the metal substrate 12b.

Different from the first embodiment only in the configuration of the metal substrate 12b, this embodiment produces the same effects as the first embodiment, although a detailed description thereof will be omitted.

[0086] Next, a fourth embodiment of the invention will be described.

Fig. 4 is a cross section schematically illustrating a solar cell submodule that is a fourth embodiment of the photoelectric converter according to the invention.

The same components of this embodiment as those of the solar cell submodule 10 according to the first embodiment illustrated in Fig. 1 are given like reference characters, and a detailed description thereof will be omitted.

[0087] As illustrated in Fig. 4, a solar cell submodule 10c has a metal substrate 12c that is different from its counterpart of the solar submodule 10 (see Fig. 1) according to the first embodiment; the other components and configuration are similar to those of the solar submodule 10 (see Fig. 1) according to the first embodiment, and their description will be omitted.

[0088] The metal substrate 12c of the solar cell submodule 10c according to this embodiment illustrated in Fig. 4 is composed solely of an aluminum substrate 38 provided with the insulation layers 18, 19 formed of anodized films on the top side 38a and the bottom side 38b of the aluminum substrate 38, respectively.

Also in this embodiment, the insulation layer 18 is not formed on either of end portions 39a, 39b of the aluminum substrate 38 on the top side 38a.

Likewise, the insulation layer 19 is also not formed on either of end portions 39c, 39d on the backside 38b of the aluminum substrate 38.

[0089] Such regions without the insulation layers 18, 19 may be formed by first forming the insulation layers 18, 19, and subsequently removing the corresponding parts of the insulation layers 18, 19 by, say, laser scribing.

Alternatively, where the insulation layers 18, 19 are formed by anodization, the regions without the insulation layers 18, 19 may be formed by masking both end portions and the lateral portions of the metal substrate 12c to inhibit formation of the insulation layers 18, 19.

[0090] The leftmost back electrode 21 as seen in Fig. 4 is connected to the end portion 39b of the aluminum substrate 38 without the insulation layer 18, and thus electrically connected to the aluminum substrate 38.

The second conductive member 34 is connected to the end portion 39a of the aluminum substrate 38 without the insulation layer 18 and thus electrically connected to the metal substrate 38. Thus, according to this embodiment, current flows likewise from the back electrode 21 to the second conductive member 34 through the metal substrate 12c acting as a conductor. Also in this case, the first conductive member 32 has a negative polarity, and the second conductive member 34 has a positive polarity.

According to this embodiment, for example, the regions of the aluminum layer 16 other than where the insulations 18, 19 are to be formed are masked before anodization to form the insulation layers 18, 19.

[0091] Different from the first embodiment only in the configuration of the metal substrate 12c, this embodiment produces the same effects as the first embodiment, although a detailed description thereof will be omitted.

Use of the aluminum substrate 38 for forming the metal substrate 12c makes this embodiment preferable where heat resistance is not required in the manufacturing process and in use environment.

The metal substrate 12c has a single-plate structure in lieu of a clad structure and as such permits reduction of material costs as compared with the first embodiment.

[0092] The aluminum layer 38 according to this embodiment may be formed using, for example, an alloy of a Class 1000 pure aluminum as defined by Japan Industrial Standard (JIS), an Al-Mn alloy, an Al-Mg alloy, an Al-Mn-Mg alloy, an Al-Zr alloy, an Al-Si alloy, or an Al-Mg-Si alloy and another metallic element (see "Aluminum Handbook, 4th edition)" (published in 1990 by Japan Light Metal Association). The aluminum substrate 38 may contain a trace amount of a metallic element such as Fe, Si, Mn, Cu, Mg, Cr, Zn, Bi, Ni, and Ti.

The aluminum substrate 38 may, for example, contain aluminum as a principal component. To contain aluminum as a principal component herein indicates an aluminum content of 90 mass% or more.

[0093] The aluminum substrate 38 typically has a thickness of 0.1 mm to 10 mm. Where the aluminum substrate 38 is used, the thicknesses thereof decreases as it undergoes anodization, washing prior to anodization, and polishing. Therefore, the thickness thereof needs to allow for such reduction in thickness.

[0094] Where the aluminum substrate 38 is used, the insulation layers 18, 19 can be formed by anodization followed by a specific pore sealing treatment. The process of manufacturing the insulation layers 18, 19 may include various steps in addition to the essential steps.

According to this embodiment, the insulation layers 18, 19 may for example be formed through a process including a degreasing step of removing attached rolling oil, a desmutting step of dissolving smut on the surface of the aluminum plate, a surface roughening step of roughening the surface of the aluminum plate, an anodizing step of forming anodized films on the surfaces of the aluminum plate, and a pore sealing step of sealing the micropores of the anodized films.

[0095] Next, a fifth embodiment of the invention will be described.

Fig. 5 is a cross section schematically illustrating a solar cell submodule that is a fifth embodiment of the photoelectric converter according to the invention.

The same components of this embodiment as those of the solar cell submodule 10 according to the first embodiment illustrated in Fig. 1 are given like reference characters, and a detailed description thereof will be omitted.

[0096] As illustrated in Fig. 5, a solar cell submodule 10d has a metal substrate 12d that is different from its counterpart of the solar submodule 10 (see Fig. 1) according to the first embodiment; the other components and configuration are similar to those of the solar submodule 10 (see Fig. 1) according to the first embodiment, and their description will be omitted.

[0097] The metal substrate 12d of the solar cell submodule 10d according to this embodiment illustrated in Fig. 5 is composed solely of the aluminum substrate 38, which has the insulation layer 18 formed of an anodized film only on the top side 38a thereof.

Also in this embodiment, the insulation layer 18 is not formed on either of the end portions 39a, 39b of the aluminum substrate 38 on the top side 38a.

Regions without the insulation layer 18 may be secured, for example, by masking the end portions of the top side, the lateral sides, and the backside of the metal substrate 12d before anodization.

[0098] The leftmost back electrode 21 as seen in Fig. 5 is connected to the end portion 39b of the aluminum substrate 38 without the insulation layer 18 and thus electrically connected to the aluminum substrate 38.

The second conductive member 34 is connected to the end portion 39a of the aluminum substrate 38 without the insulation layer 18 and thus electrically connected to the aluminum substrate 38.

[0099] Different from the first embodiment only in the configuration of the metal substrate 12d, this embodiment produces the same effects as the first embodiment, although a detailed description thereof will be omitted.

Use of the aluminum substrate 38 for forming the metal substrate 12d makes this embodiment preferable where heat resistance is not required in the manufacturing process and in use environment.

The metal substrate 12d has a single-plate structure in lieu of a clad structure and as

such permits reduction of material costs as compared with the first embodiment. According to this embodiment, the aluminum substrate 38 may be the same as the aluminum substrate 38 of the fourth embodiment.

[0100] Next, a sixth embodiment of the invention will be described.

Fig. 6A is a cross section schematically illustrating a solar cell submodule that is a sixth embodiment of the photoelectric converter according to the invention; Fig. 6B is a top plan view schematically illustrating a solar cell submodule that is the sixth embodiment of the photoelectric converter according to the invention

The same components of this embodiment as those of the solar cell submodule 10 according to the first embodiment illustrated in Fig. 1 are given like reference characters, and a detailed description thereof will be omitted.

[0101] As illustrated in Fig. 6A, a solar cell submodule 10e has the first conductive member 32 disposed in a position that is different from that of its counterpart of the solar submodule 10 (see Fig. 1) according to the first embodiment; the other components and configuration are similar to those of the solar submodule 10 (see Fig. 1) according to the first embodiment, and their description will be omitted.

[0102] In the solar cell submodule 10 according to the first embodiment illustrated in Fig. 1, the first conductive member 32 is connected to the surface 26a of the transparent electrode 26 of the photoelectric conversion element 30 that is disposed on the rightmost back electrode 20a. According to this embodiment, the first conductive member 32 is disposed immediately on the rightmost back electrode 20a as illustrated in Fig. 6A.

To that end, the photoelectric conversion element 30 formed on the back electrode 20a of interest may be removed by, say, laser scribing or mechanical scribing technique to expose the back electrode 20a.

[0103] Different from the first embodiment only in the position of the first conductive member 32, this embodiment produces the same effects as the first embodiment, although a detailed description thereof will be omitted.

Further, the first conductive member 32 formed immediately on the back electrode 20a allows the first conductive member 32 and the second conductive member 34 to have substantially the same height. Therefore, the first conductive member 32 and the second conductive member 34 may be connected to a terminal box at the same height, so that the terminal box can be made thinner. Further, the above configuration facilitates wiring required to connect the first conductive member 32 and the second conductive member 34 by wiring the lines onto the backside when forming the solar cell sub-module 10e illustrated in Fig. 6B into a solar cell module.

[0104] Although the first conductive member 32 is formed immediately on the back electrode 20a according to this embodiment, the first conductive member 32 may be

likewise formed immediately on the back electrode 20a according to the first to fifth embodiments described above.

[0105] Next, a seventh embodiment of the invention will be described.

Fig. 7 is a cross section schematically illustrating a solar cell submodule that is a seventh embodiment of the photoelectric converter according to the invention.

The same components of this embodiment as those of the solar cell submodule 10 according to the first embodiment illustrated in Fig. 1 are given like reference characters, and a detailed description thereof will be omitted.

[0106] As illustrated in Fig. 7, a solar cell submodule 10f is different from the solar submodule 10 (see Fig. 1) according to the first embodiment in the configuration of a metal substrate 12e and the position of the second conductive member 34; the other components and configuration are similar to those of the solar submodule 10 (see Fig. 1) according to the first embodiment, and their description will be omitted.

[0107] The metal substrate 12e of the solar cell submodule 10f according to this embodiment illustrated in Fig. 7 is composed solely of the aluminum substrate 38, which has the insulation layer 18 formed of an anodized film on the top side 38a thereof.

Also in this embodiment, the insulation layer 18 is not formed on either of the end portions 39a, 39b of the aluminum substrate 38 on the top side 38a.

Such regions without the insulation layer 18 may be formed by first forming the insulation layer 18 and subsequently removing the insulation layers 18 by, say, laser scribing.

Where the insulation layer 18 is formed by anodization, the regions without the insulation layer 18 may alternatively be formed by masking both end portions, the lateral portions, and the backside of the metal substrate 12c.

[0108] The leftmost back electrode 21 as seen in Fig. 7 is connected to the end portion 39b of the aluminum substrate 38 without the insulation layer 18 and thus electrically connected to the aluminum substrate 38.

The second conductive member 34 is provided on the backside 38b of the aluminum substrate 38 and electrically connected to the aluminum substrate 38.

[0109] Different from the first embodiment only in the composition of the metal substrate 12e and the position of the second conductive member 34, this embodiment produces the same effects as the first embodiment, although a detailed description thereof will be omitted.

While the first embodiment requires routing the lines from the first conductive member 32 and the second conductive member 34 onto the back surface 14b to obtain a solar cell module, this embodiment, where the second conductive member 34 is provided on the backside 38b of the aluminum substrate 38b, obviates the need of routing the line from the second conductive member 34 onto the backside, thus in-

creasing the work efficiency. Further, since additional wiring for connecting the second conductive member 34 to the backside is not required, the whole length of wiring can be shortened and hence the material costs can be reduced.

[0110] Use of the aluminum substrate 38 for forming the metal substrate 12e makes this embodiment preferable where heat resistance is not required in the manufacturing process and in use environment.

The metal substrate 12e has a single-plate structure in lieu of a clad structure and as such permits reduction of material costs as compared with the first embodiment.

According to this embodiment, the metal substrate is not specifically limited in configuration and may be replaced by the metal substrate 12 of the first embodiment, the metal substrate 12a of the second embodiment, the metal substrate 12b of the third embodiment, the metal substrate 12c of the fourth embodiment, or the metal substrate 12c of the fifth embodiment.

[0111] Next, an eighth embodiment of the invention will be described.

Fig. 8 is a cross section schematically illustrating a solar cell submodule that is an eighth embodiment of the photoelectric converter according to the invention.

The same components of this embodiment as those of the solar cell submodule 10 according to the first embodiment illustrated in Fig. 1 are given like reference characters, and a detailed description thereof will be omitted.

[0112] As illustrated in Fig. 8, a solar cell submodule 10g is different from the solar submodule 10 (see Fig. 1) according to the first embodiment in the position of the first conductive member 32, the position of the second conductive member 34, the position where a back electrode 41 and the metal substrate 12 are connected, and the configuration of photoelectric conversion elements 50; the other components and configuration are similar to those of the solar submodule 10 (see Fig. 1) according to the first embodiment, and their description will be omitted.

[0113] The photoelectric conversion elements 50 of the solar cell submodule 10g according to this embodiment illustrated in Fig. 8 is of tandem type and comprises back electrodes 40, 41, photoelectric conversion layers 42, and the transparent electrodes 26. The photoelectric conversion elements 50 are separated from each other by opening grooves (P3) 51 reaching the back electrodes 40.

The back electrodes 40 are provided on the surface 18a of the insulation layer 18 and share separation groove (P1) 43 of a given width with adjacent back electrodes 40, 41. The back electrodes 40, 41 comprise an Ag layer 40a and ZnO layer 40b superposed in this order, the former being closer to the metal substrate 12. The transparent electrodes 26 are formed of ITO, for example.

[0114] The photoelectric conversion layers 42 are formed, for example, of two photoelectric conversion cells 44a, 44b superposed on each other, each having different light ab-

sorption characteristics. The first photoelectric conversion cell 44a is closer than the second photoelectric conversion cell 44b to the metal substrate 12 and has absorption characteristics such that it absorbs light having a longer wavelength band than the second photoelectric conversion cell 44b.

The first photoelectric conversion cell 44a is provided on the back electrode 40 and comprises an n-type semiconductor layer 52, an intrinsic semiconductor layer 54a, and a p-type semiconductor layer 56 superposed in this order, the n-type semiconductor layer 52 being the closest to the metal substrate 12. The intrinsic semiconductor 54a may for example be formed of microcrystalline silicon or amorphous silicon germanium.

[0115] The second photoelectric conversion cell 44b is provided on the first photoelectric conversion cell 44a and comprises an n-type semiconductor layer 52, an intrinsic semiconductor layer 54b, and a p-type semiconductor layer 56 superposed in this order, the n-type semiconductor layer 52 being the closest to the metal substrate 12. The intrinsic semiconductor 54b may for example be formed of amorphous silicon.

The photoelectric conversion layers 42 have a groove (P2) 45 reaching the back electrodes 40. The grooves (P2) 45 are filled with the transparent electrodes 26.

According to this embodiment, the side of each photoelectric conversion element 50 closer to the transparent electrode 26 is positive, and the side closer to the back electrode 40 is negative. Thus, the first conductive members 32 are negative, and the second conductive member 34 is positive. Although the photoelectric conversion layers 42 described above have a laminate structure comprising two photoelectric conversion cells 44a, 44b having different light absorption characteristics by way of example, the photoelectric conversion layers 42 are not limited this way and may have a structure having three or more layers.

[0116] According to this embodiment, the back electrodes 41 are connected to the metal substrate 12 through the end portion 16a not provided with the insulation layer 18.

According to this embodiment, the second conductive member 34 is connected through an electrode 58 to the metal substrate 12 at the end portion 16b without the insulation layer 18. Thus, the second conductive member 34 and the rightmost photoelectric conversion element 50 as seen in Fig. 8 are electrically connected through the aluminum layer 16 and the stainless steel plate 14 of the metal substrate 12.

[0117] The first conductive member 32 is connected to the leftmost back electrode 40 as seen in Fig. 8. To that end, the photoelectric conversion element 50 formed on the leftmost back electrode 40 is removed by, say, laser scribing or mechanical scribing technique to expose the back electrode 40.

The electrode 58 has the same configuration as the back electrode 40. The second conductive member 34 may be formed immediately on the end portion 16b of the

metal substrate 12 without providing the electrode 58.

- [0118] Using the metal substrate 12 as a conductor, this embodiment, while different from the first embodiment in the position of the first conductive member 32, the position of the second conductive member 34, the position where the applicable back electrode 41 and the metal substrate 12 are connected, and the configuration of the photoelectric conversion elements 50, produces substantially the same effects as the first embodiment, although a detailed description thereof will be omitted.

Further, according to this embodiment, the first conductive member 32 formed immediately on the leftmost back electrode 40 allows the first conductive member 32 and the second conductive member 34 to have substantially the same height. Thus, the above configuration facilitates wiring required to route the lines from the first conductive member 32 and the second conductive member 34 onto the backside when forming the solar cell submodule 10g into a solar cell module.

- [0119] According to this embodiment, the metal substrate is not specifically limited in configuration and may be replaced by the metal substrate 12a of the second embodiment, the metal substrate 12b of the third embodiment, the metal substrate 12c of the fourth embodiment, or the metal substrate 12d of the fifth embodiment.

- [0120] Next, a ninth embodiment of the invention will be described.

Fig. 9 is a cross section schematically illustrating a solar cell submodule that is a ninth embodiment of the photoelectric converter according to the invention.

The same components of this embodiment as those of the solar cell submodule 10 according to the first embodiment illustrated in Fig. 1 are given like reference characters, and a detailed description thereof will be omitted.

- [0121] As illustrated in Fig. 9, a solar cell submodule 10h has photoelectric conversion elements 60 that are different from their counterparts of the solar submodule 10 (see Fig. 1) according to the first embodiment; the other components and configuration are similar to those of the solar submodule 10 (see Fig. 1) according to the first embodiment, and their description will be omitted.

- [0122] The photoelectric conversion elements 60 of the solar cell submodule 10h according to this embodiment illustrated in Fig. 9 each have a photoelectric conversion layer 62 of CdTe (cadmium telluride) type that is different from the photoelectric conversion layer 22 of CIG type according to the first embodiment in the composition of CdTe. The photoelectric conversion elements 60 otherwise have the same configuration as the photoelectric conversion elements 30 of the first embodiment. Therefore, a detailed description thereof will be omitted.

The photoelectric conversion layers 62 of CdTe type may be produced by any of known methods.

Different from the first embodiment only in the configuration of the photoelectric

conversion layers 62, this embodiment produces the same effects as the first embodiment, although a detailed description thereof will be omitted.

[0123] As with the solar cell submodules 10 according to the first embodiment (see Fig. 1), the top side of the solar cell submodules 10a to 10h is provided with a bond/seal layer, a water vapor barrier layer, and a surface protection layer; the backside of the solar cell modules 10a to 10h is provided with a bond/seal layer and a back sheet. Subsequently, these layers are integrated with the solar cell submodule by vacuum laminating treatment according to a vacuum laminating technique to obtain a solar cell module.

[0124] As illustrated in Fig. 6B, the first conductive member 32 and the second conductive member 34 extend parallel to each other and are longer along a side of the metal substrate 12 according to any of the above embodiments. As illustrated in Fig. 6B, at least the back electrode 21 connected to the second conductive member 34 preferably has a length X not less than a half of L , the length of a side of the metal substrate 12 in any of the above embodiments. Thus, a good conductivity can be ensured between the back electrode 21 and the metal substrate 12.

[0125] In any of the above embodiments, the metal substrate is rectangular and the end portions of at least two sides thereof each preferably have a region without the insulation layer, so that the metal substrate is exposed. In this case, the two sides preferably are two opposite sides.

Further, in any of the above embodiments, the metal substrate is rectangular and the end portions of at least two sides thereof each may have a conductor connected to a conductive portion of the metal substrate. Also in this case, the two sides preferably are two opposite sides.

[0126] Although the photoelectric converter of the invention has been described based upon the embodiments represented by solar cell submodules by way of example, wherein the photoelectric conversion device is a so-called integrated type solar battery device comprising photoelectric conversion elements (solar cells) connected in series, the invention is not limited this way. The invention may also be applied, for example, to an optical sensor having an integrated structure such that it is capable of an amplifying effect. Further, according to the invention, the photoelectric conversion device may be one comprising organic EL emitting elements, and the photoelectric converter may be an organic EL display.

Further, in any of the above embodiments, the photoelectric conversion device may be one comprising thin-film type thin-film solar cells or thin-film type photoelectric conversion elements, or integrated type solar cells or integrated type thin-film photoelectric conversion elements.

[0127] In any of the above embodiments, the photoelectric conversion elements of the solar cell submodule are not specifically limited to CIGS based photoelectric conversion

elements, tandem structured photoelectric conversion elements, or CdTe based photoelectric conversion elements and may for example be thin-film silicon based thin-film solar cell, thin-film silicon based photoelectric conversion element, dye-sensitized solar cell, dye-sensitized photoelectric conversion element, organic solar cell, or organic photoelectric conversion element.

[0128] The present invention is basically as described above. While the photoelectric converter of the invention has been described above in detail, the present invention is by no means limited to the above embodiments, and various improvements or design modifications may be made without departing from the scope and spirit of the present invention.

LEGEND

[0129] 10, 10a to 10h solar cell submodule
12 a metal substrate
14 stainless steel plate
16, 17 aluminum layer
16a, 16b both end portion
18, 19 insulation layer
20, 40 back electrode
22, 42 photoelectric conversion layer
24 buffer layer
26 transparent electrode
30, 50, 60 photoelectric conversion element
32 first conductive member
34 second conductive member
38 aluminum substrate
58 electrode

Claims

- [Claim 1] A photoelectric converter comprising:
a metal substrate including a conductive portion acting as an electrical conductor and an electrical insulation layer formed on at least a surface of the conductive portion;
a photoelectric conversion device formed on the insulation layer;
a first conductive member connected to one electrode of a positive electrode and a negative electrode of the photoelectric conversion device for pulling out an output of the photoelectric conversion device from the one electrode to an outside;
an electric connection portion for connecting the other electrode of the positive electrode and the negative electrode of the photoelectric conversion device to the conductive portion of the metal substrate; and
a second conductive member for pulling out the output from the other electrode via the electric connection portion and the conductive portion of the metal substrate to the outside, the second conductive member being connected directly or indirectly to the conductive portion of the metal substrate so as to be electrically connected to the other electrode through the conductive portion of the metal substrate and the electric connection portion, wherein
the second conductive member is connected to a position of the conductive portion of the metal substrate.
- [Claim 2] The photoelectric converter according to Claim 1, wherein
the first conductive member and the second conductive member are provided close to each other.
- [Claim 3] The photoelectric converter according to Claim 1 or 2, wherein
the metal substrate does not have the insulation layer at end portions of the conductive portion, and
the other electrode is connected through the electric connection portion to the end portions of the conductive portion.
- [Claim 4] The photoelectric converter according to any one of Claims 1 to 3, wherein
the metal substrate is substantially rectangular,
electrical conductors are provided end portions of at least two sides of the metal substrate electrically connected with the conductive portion, and
the second conductive member is connected to the electrical conductors

and electrically connected to the conductive portion via the electrical conductors.

[Claim 5] The photoelectric converter according to any one of Claims 1 to 3, wherein
the metal substrate is substantially rectangular,
end portions of at least two sides of the metal substrate are provided with regions of the conductive portion where the insulation layer is not formed, and
the second conductive member is connected directly to regions of the conductive portion.

[Claim 6] The photoelectric converter according to any one of Claims 1 to 5, wherein
the metal substrate is substantially rectangular,
the photoelectric conversion device is provided with the positive and negative electrodes parallel to one side of the metal substrate, and
the positive and negative electrodes have a length that is not less than a half of the length of the one side of the metal substrate.

[Claim 7] The photoelectric converter according to any one of Claims 1 to 6, wherein
the metal substrate is substantially rectangular,
the insulation layer is not formed at two opposite sides of the metal substrate,
the photoelectric conversion device is provided with the positive and negative electrodes at both ends thereof,
the other electrode of the positive and negative electrodes is connected to the conductive portion provided on one side of the two opposite sides through the electric connection portion,
the second conductive member is connected to the conductive portion on the other side of the two opposite sides, and
the other electrode of the photoelectric conversion device is electrically connected to the second conductive member through the electric connection portion and the conductive portion of the metal substrate.

[Claim 8] The photoelectric converter according to any one of Claims 1 to 7, wherein
the photoelectric conversion device comprises series-connected photoelectric conversion elements, and
a potential of electricity at the negative electrode or the positive electrode pulled out from the second conductive member to the outside

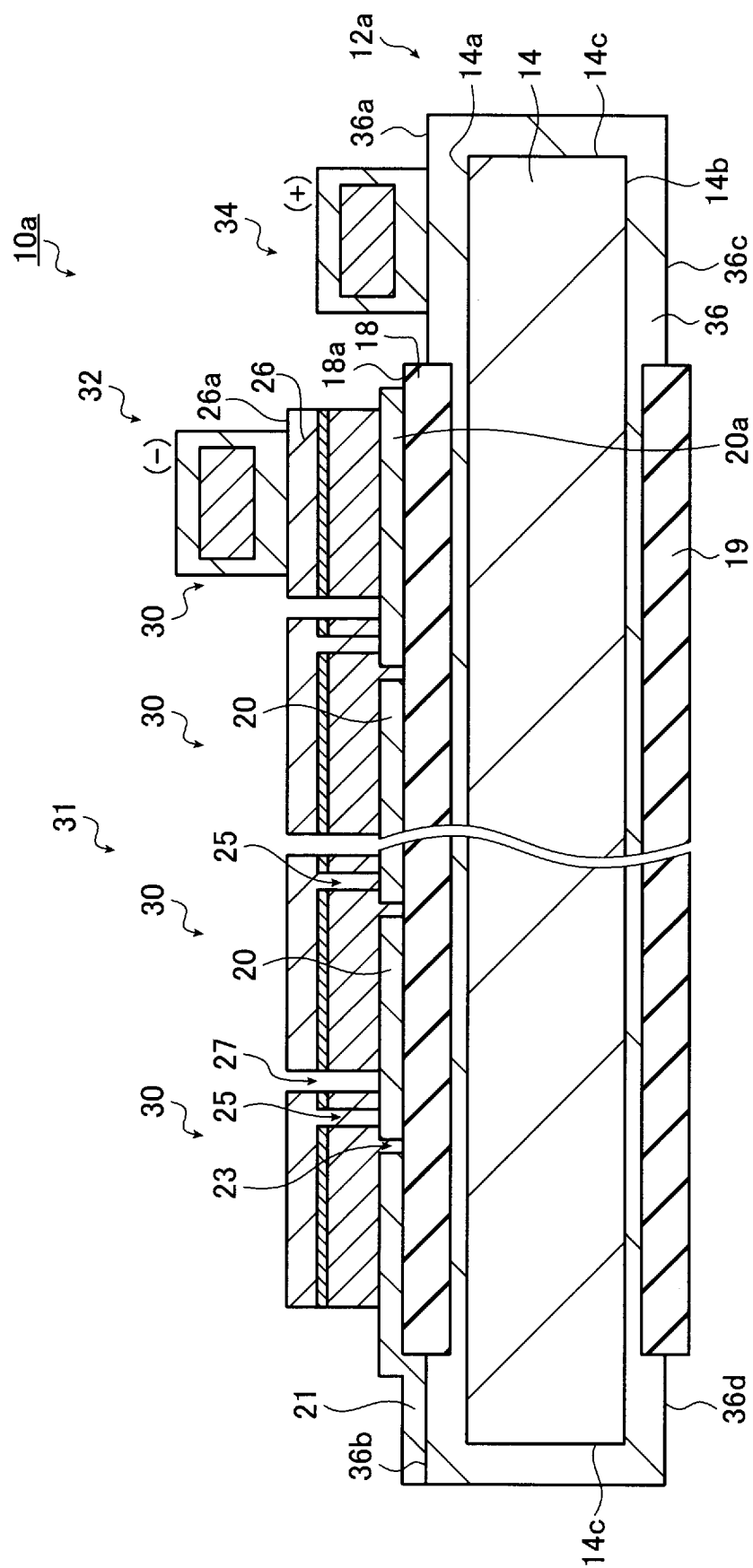
- is substantially equal to a maximum potential of all the photoelectric conversion elements in the photoelectric conversion device.
- [Claim 9] The photoelectric converter according to any one of Claims 1 to 8, wherein the photoelectric conversion device is an integrated type comprising series-connected solar cells.
- [Claim 10] The photoelectric converter according to any one of Claims 1 to 9, wherein the photoelectric conversion device comprises solar cells of a thin-film type.
- [Claim 11] The photoelectric converter according to any one of Claims 1 to 10, wherein the photoelectric conversion device comprises one kind of solar cells of a thin-film type selected from the group consisting of CIS based thin-film solar cells, CIGS based thin-film solar cells, thin-film silicon based thin-film solar cells, CdTe based thin-film solar cells, III-V group based thin-film solar cells, dye-sensitized thin-film solar cells, and organic thin-film solar cells.
- [Claim 12] The photoelectric converter according to any one of Claims 1 to 11, wherein the photoelectric conversion device comprises substrate type thin-film solar cells.
- [Claim 13] The photoelectric converter according to any one of Claims 1 to 12, wherein the metal substrate has the insulation layer formed on both sides or one side thereof.
- [Claim 14] The photoelectric converter according to any one of Claims 1 to 13, wherein the insulation layer is formed of at least one of aluminum oxide, silicon oxide, and resin.
- [Claim 15] The photoelectric converter according to any one of Claims 1 to 14, wherein the metal substrate contains aluminum as a principal component.
- [Claim 16] The photoelectric converter according to any one of Claims 1 to 15, wherein the metal substrate comprises a stainless steel plate or a steel plate.
- [Claim 17] The photoelectric converter according to any one of Claims 1 to 16, wherein

the metal substrate comprises a stainless steel plate or a steel plate of the metal substrate having at least its top surface covered with aluminum.

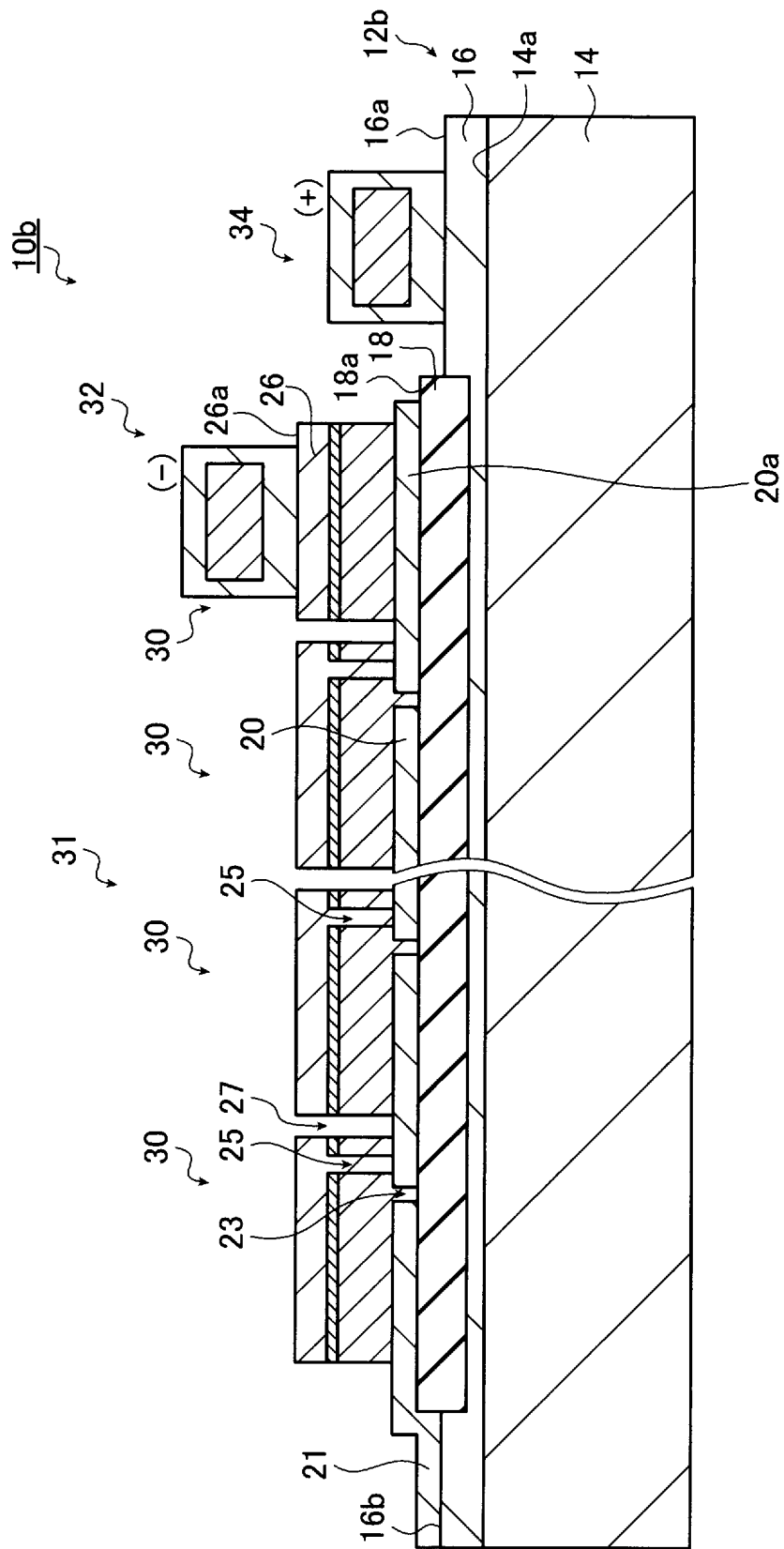
[Claim 18]

The photoelectric converter according to any one of Claims 1 to 17, wherein the insulation layer is formed of anodized aluminum.

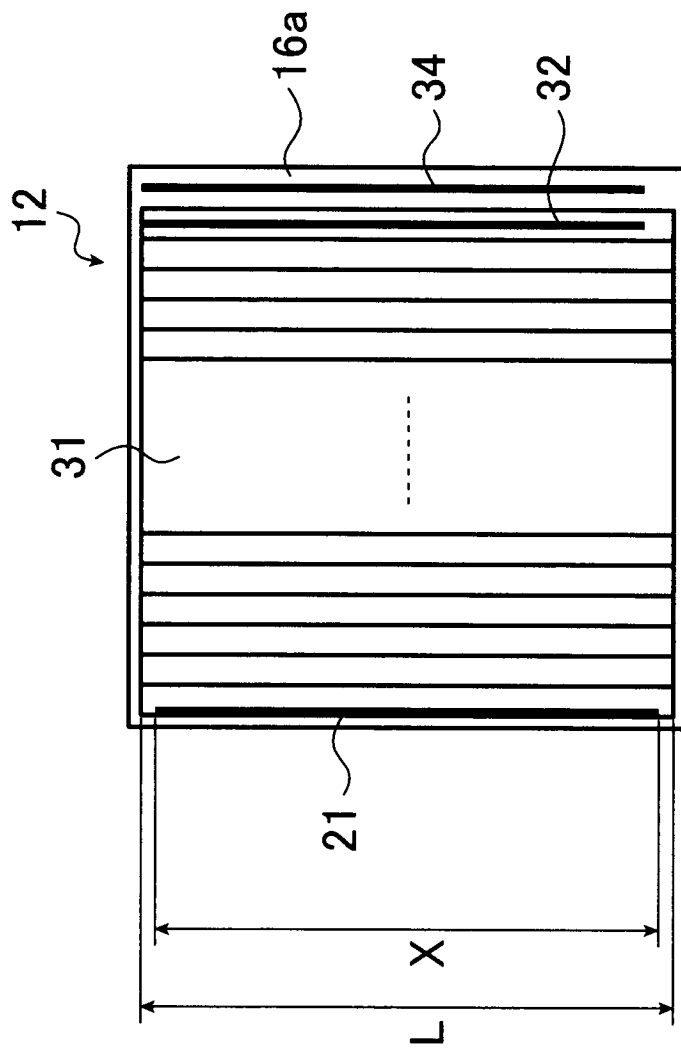
[Fig. 2]



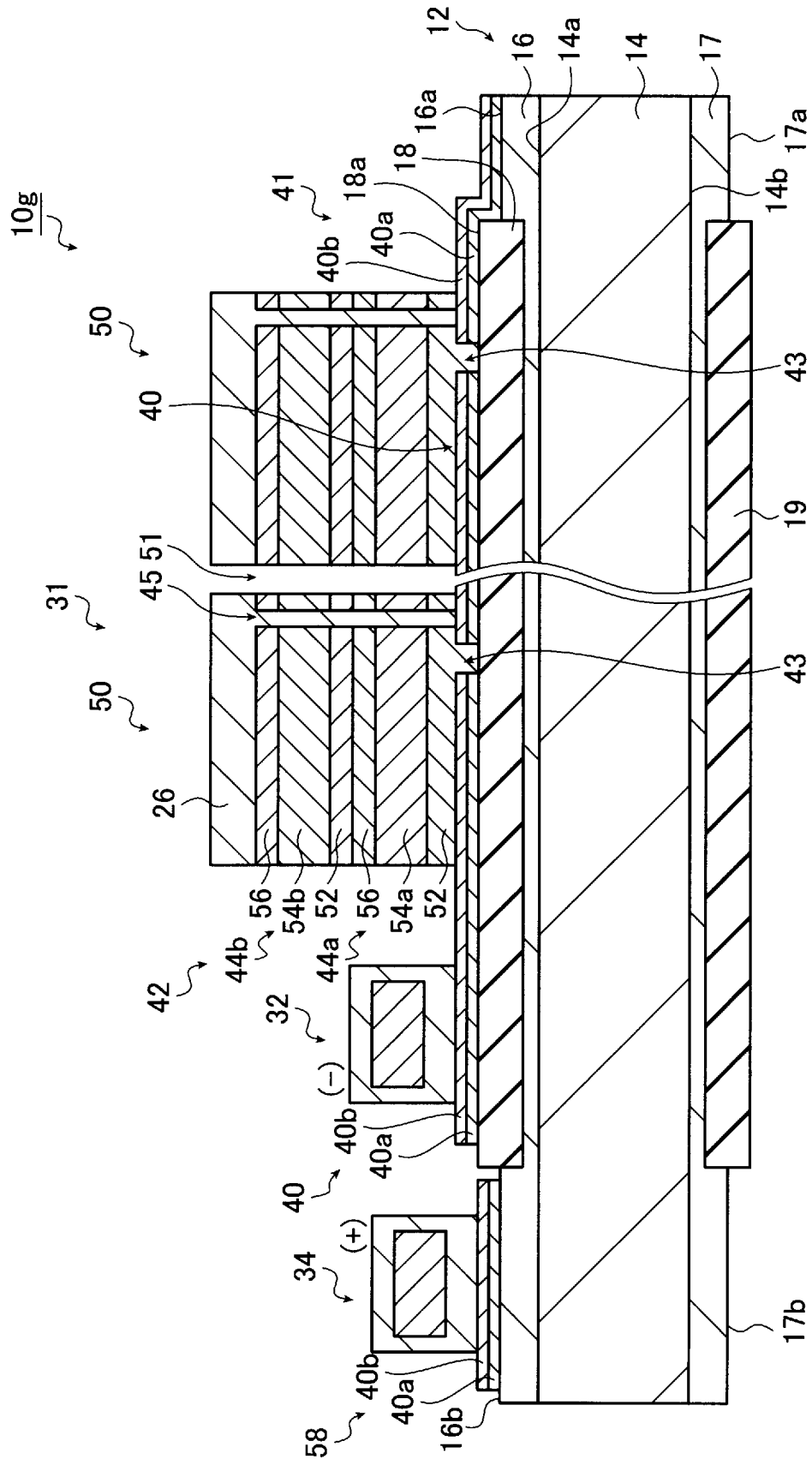
[Fig. 3]



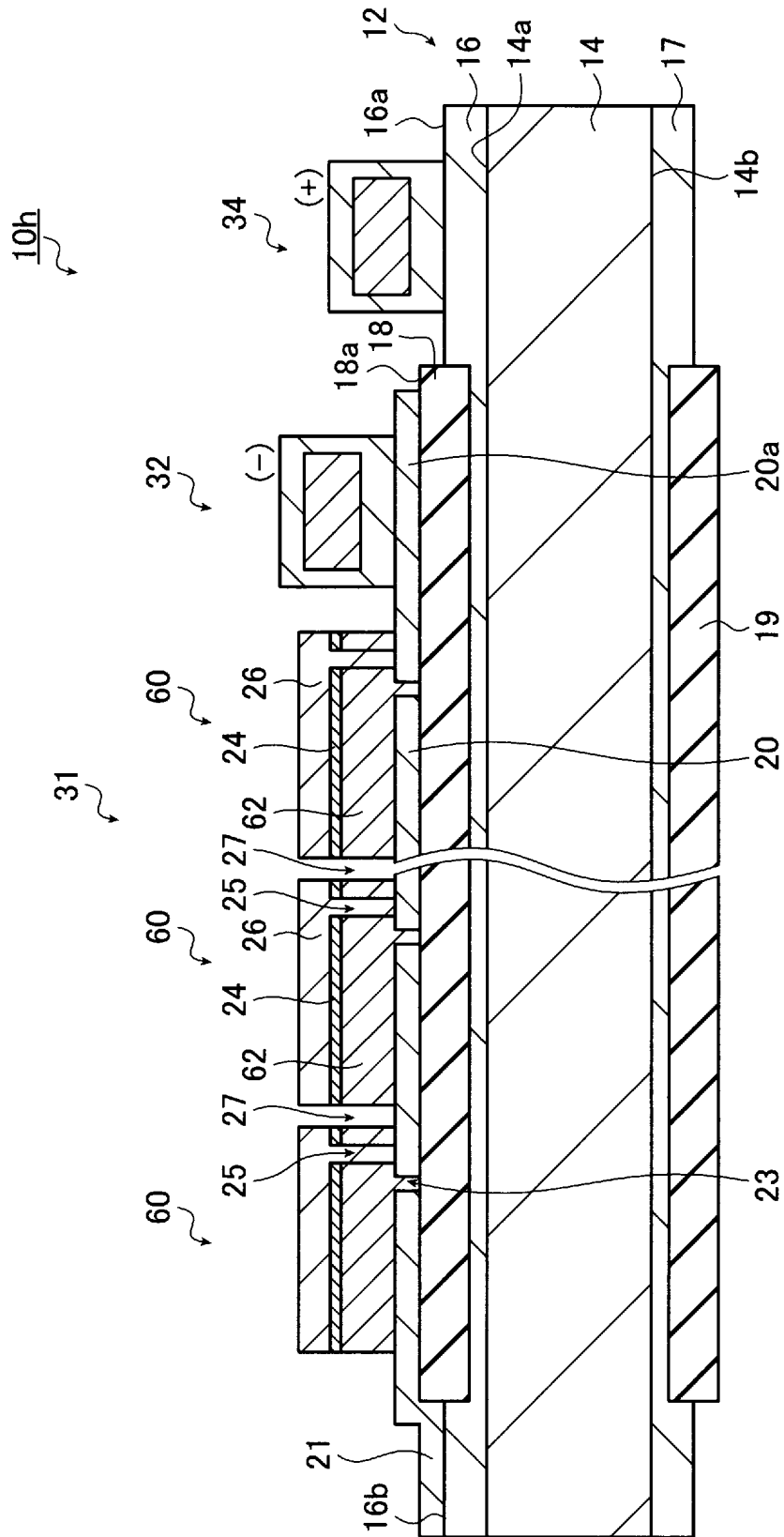
[Fig. 6B]



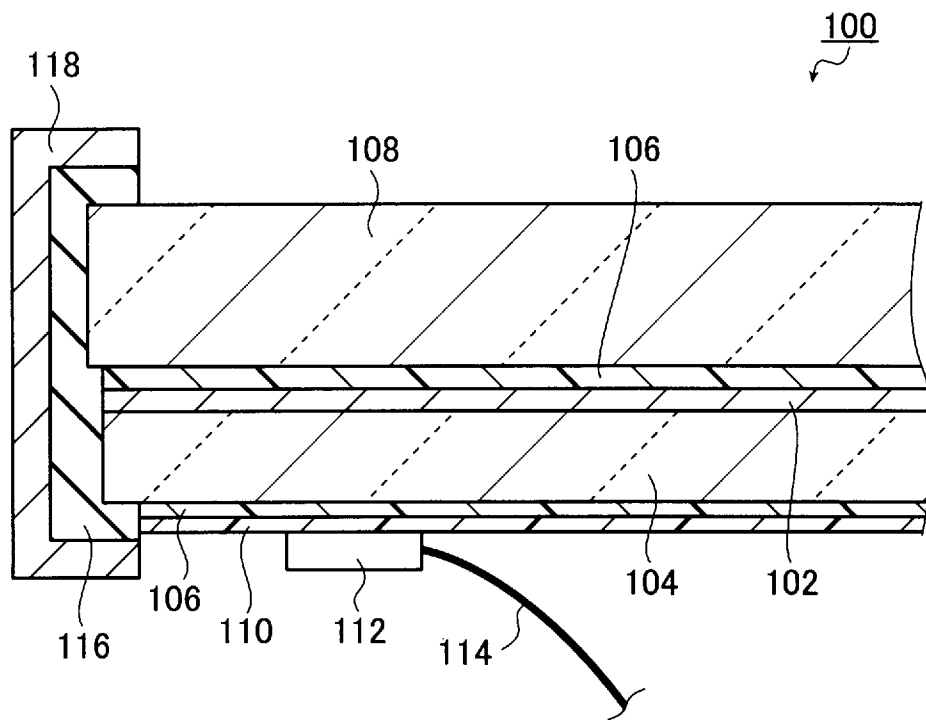
[Fig. 8]



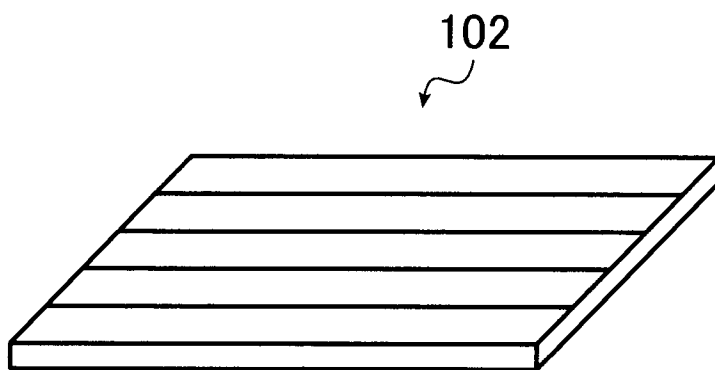
[Fig. 9]



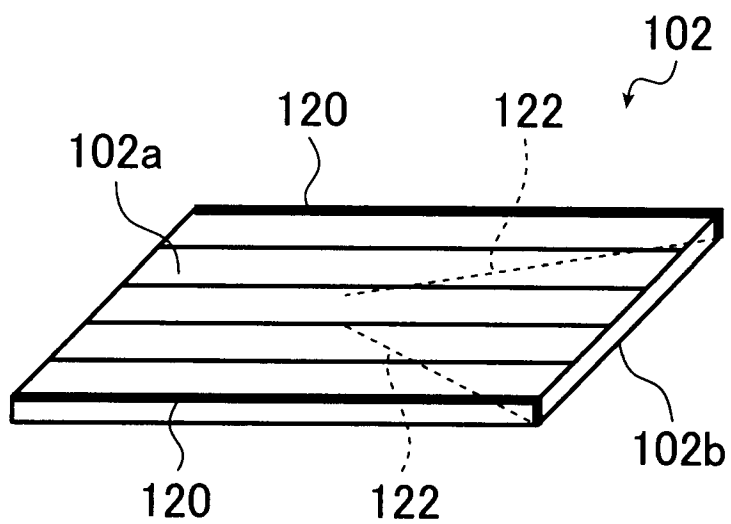
[Fig. 10]



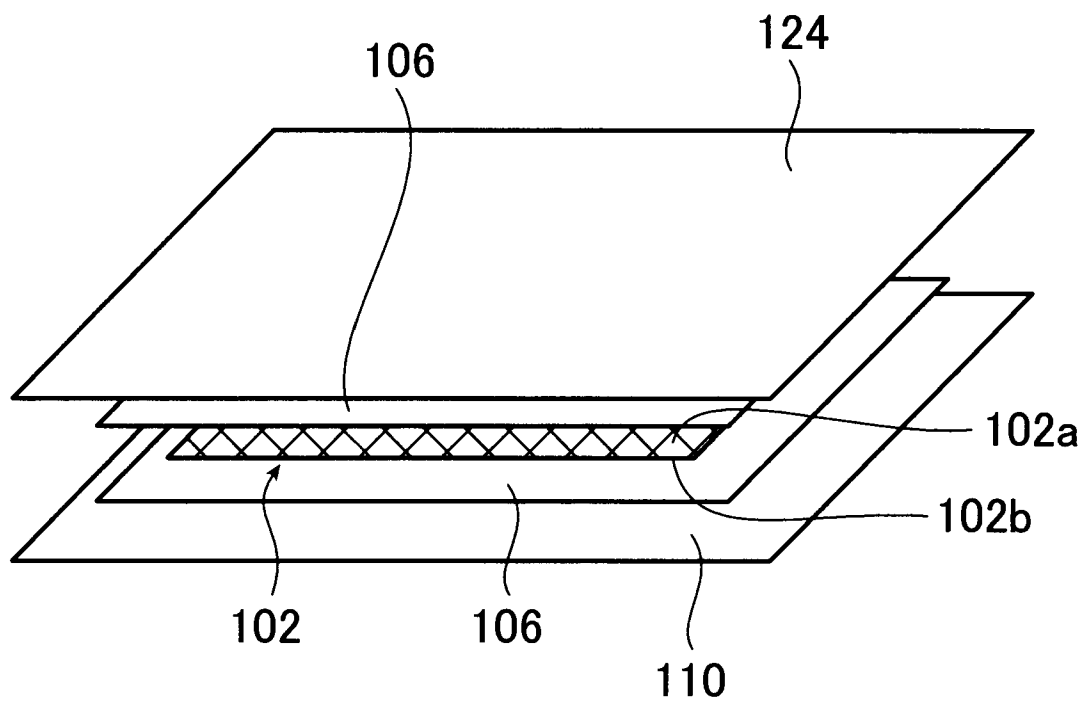
[Fig. 11A]



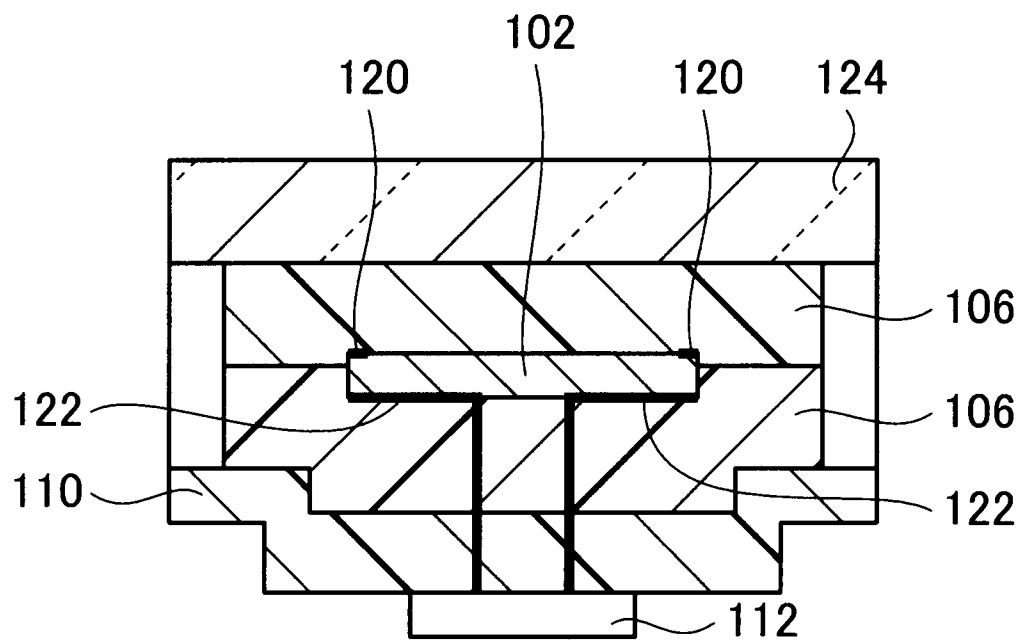
[Fig. 11B]



[Fig. 11C]



[Fig. 11D]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/005173

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H01L31/04 (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)

Int.Cl. H01L31/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2010
 Registered utility model specifications of Japan 1996-2010
 Published registered utility model applications of Japan 1994-2010

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Microfilm of the specification and drawings annexed to the written application of Japanese Utility Model Application No.073916/1988 (Laid-open No.176956/1989) (Oki Electric Industry Co., Ltd.) 1989.12.18, the 11th line in page 11 - the 13th line in page 12, Fig.6 (No Family)	1-18
X	JP 64-055877 A (TAIYO YUDEN CO., LTD.) 1989.03.02, the 3rd line - the 10th line on the lower left-hand section in page 2, the 2nd line - the 10th line on the lower left-hand section in page 3, Fig.2 (No Family)	1-18



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

06.09.2010

Date of mailing of the international search report

14.09.2010

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/005173

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the written application of Japanese Utility Model Application No.124307/1986 (Laid-open No.031553/1988) (Sharp Corporation) 1988.03.01, Fig.3 (No Family)	1-18
A	Microfilm of the specification and drawings annexed to the written application of Japanese Utility Model Application No.044408/1989 (Laid-open No.137055/1990) (SANYO Electric Co., Ltd.) 1990.04.14, Fig.1(b) (No Family)	1-18
A	JP 11-135811 A (Yazaki Corporation) 1999.05.21, Fig.5 (No Family)	6