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(54) SOLAR CELL AND SOLAR MODULE

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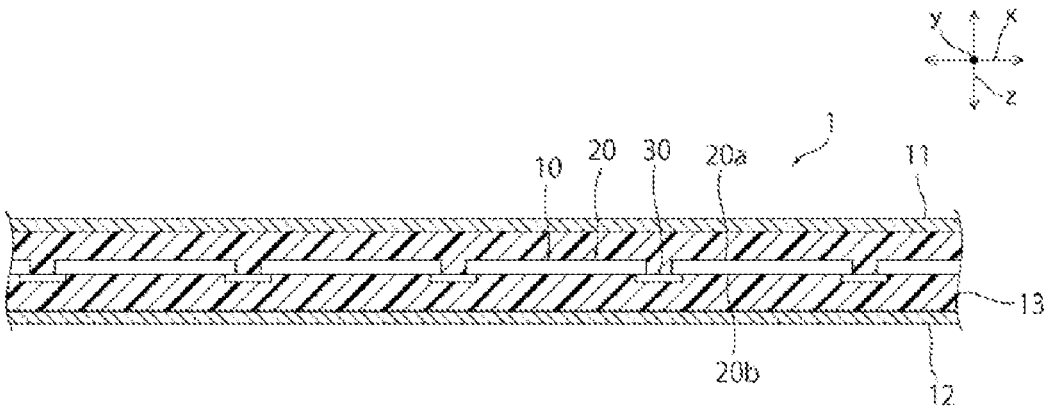
(57) **ABSTRACT**

A solar cell and a solar module are provided which have improved output characteristics. A solar cell (**20**) has a photovoltaic conversion unit (**23**), a first electrode (**21**), and a second electrode (**22**). The first electrode (**21**) and the second electrode (**22**) are arranged on one main surface of the photovoltaic conversion unit (**23**). The first electrode (**21**) has first finger portions (**21***a*) and a first busbar portion (**21***b*). The first finger portions (**21***a*) extend in one direction. The first finger portions (**21***a*) are connected electrically to the first busbar portion (**21***b*). The width (W**11**) of the first busbar portion (**21***b*) is smaller than the width (W**21**) of each first finger portion.



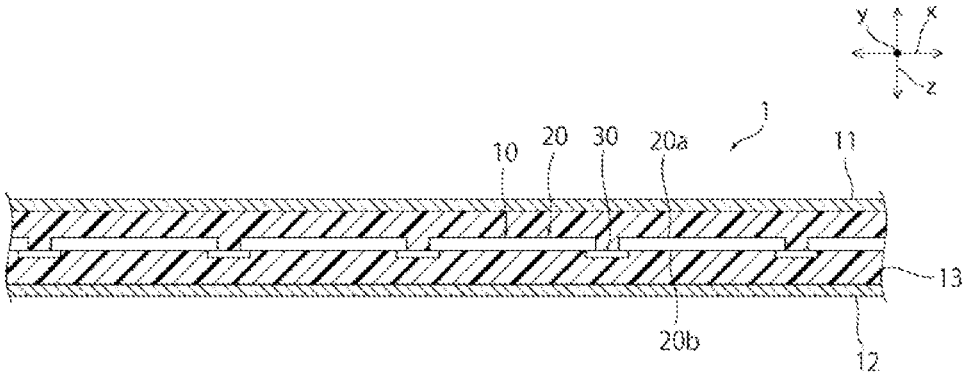


FIG. 1

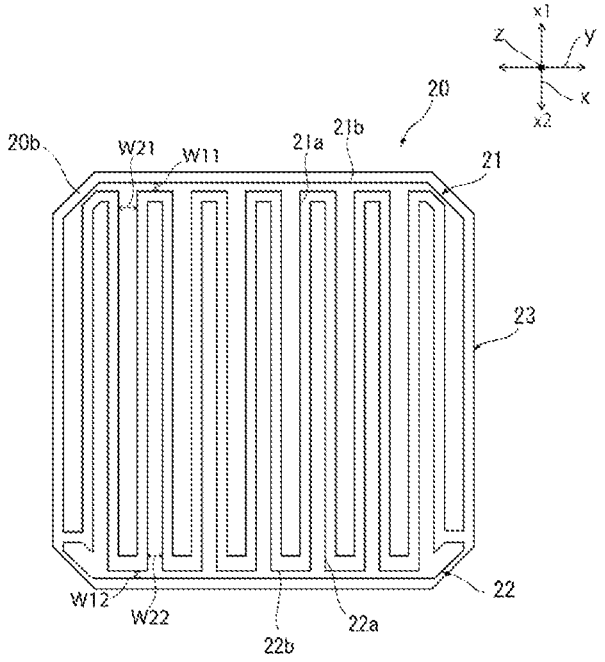

x1
z
y
x
x2
20
20b
W21
W11
21a
21b
21
23
22
W12
W22
22b
22a

FIG. 2

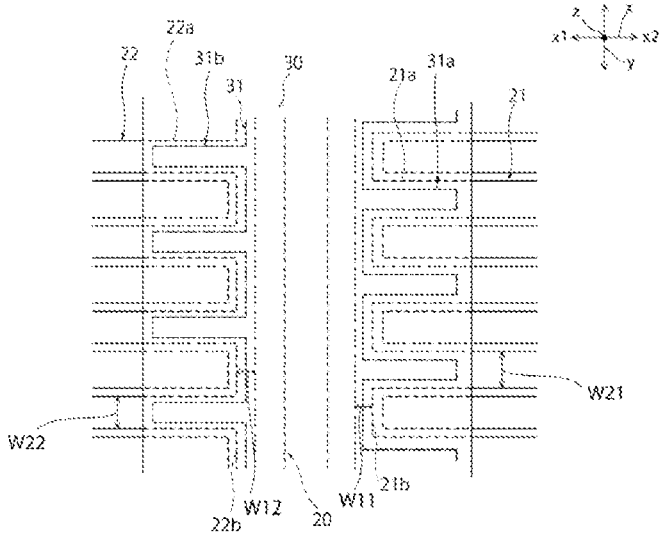

22a
22
31b
31
30
21a
31a
21
W21
W22
W12
22b
20
W11
21b

FIG. 3

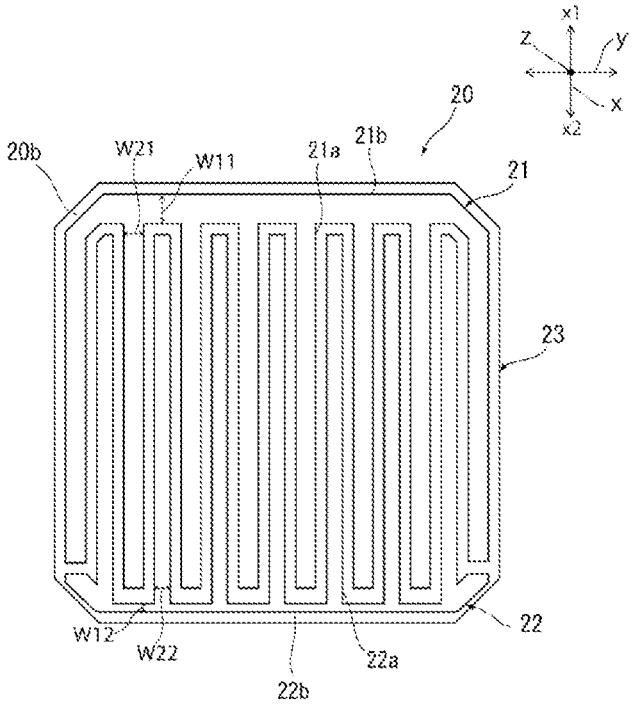


FIG. 4

SOLAR CELL AND SOLAR MODULE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This is a continuation of International Application PCT/JP2012/066731, with an international filing date of Jun. 29, 2012, filed by applicant, the disclosure of which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to a solar cell and a solar module.

BACKGROUND

[0003] Back contact solar cells such as the ones described in Patent Document 1 are conventionally known. In a back contact solar cell, an electrode does not have to be provided on the light-receiving surface. As a result, improved output characteristics have been realized using back contact solar cells.

PRIOR ART DOCUMENTS

Patent Documents

[0004] Patent Document 1: Laid-Open Patent Publication No. 2010-80887

SUMMARY

Problem Solved by the Invention

[0005] In recent years, there has been growing demand for solar cells with even better output characteristics.

Means of Solving the Problem

[0006] The solar cell of the present invention has a photovoltaic conversion unit, a first electrode, and a second electrode. The first electrode and the second electrode are arranged on one main surface of the photovoltaic conversion unit. The first electrode has a plurality of first finger portions and a first busbar portion. The first finger portions extend in one direction. The first finger portions are connected electrically to the first busbar portion. The width of the first busbar portion is smaller than the width of each first finger portion.

Effect of the Invention

[0007] The present invention is able to provide a solar cell and a solar module with improved output characteristics.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a simplified cross-sectional view of the solar module in a first embodiment.

[0009] FIG. **2** is a simplified rear view of a solar cell in the first embodiment.

[0010] FIG. **3** is a simplified rear view of the solar cell string in the first embodiment.

[0011] FIG. **4** is a simplified rear view of a solar cell in a second embodiment.

DETAILED DESCRIPTION

[0012] The following is an explanation of examples of preferred embodiments of the present invention. The following embodiments are merely examples. The present invention is not limited by the following embodiments in any way.

[0013] Further, in each of the drawings referenced in the embodiments, members having substantially the same function are denoted by the same symbols. The drawings referenced in the embodiments are also depicted schematically. The dimensional ratios of the objects depicted in the drawings may differ from those of the actual objects. The dimensional ratios of objects may also vary between drawings. The specific dimensional ratios of the objects should be determined with reference to the following explanation.

1st Embodiment

[0014] As shown in FIG. **1**, the solar module **1** includes a solar cell string **10**. The solar cell string **10** is arranged between a first protecting member **11** positioned on the light-receiving surface side, and a second protecting member **12** positioned on the back surface side. A bonding layer **13** is provided between the first protecting member **11** and the second protecting member **12**. The solar cell string **10** is sealed by the bonding layer **13**.

[0015] The first protecting member **11** can be composed of a translucent member such as a glass substrate or resin substrate. The second protecting member **12** can be composed of a glass substrate, or a resin substrate such as a resin sheet or a resin sheet containing interposed metal foil. The bonding layer **13** can be made of a resin such as an ethylene/vinyl acetate (EVA) copolymer, polyvinyl butyral (PVB), polyethylene (PE), or polyurethane (PU).

[0016] The solar cell string **10** includes a plurality of solar cells **20** arranged in the x-direction (the first direction). The solar cells **20** are connected electrically via a wiring member **30**.

[0017] Each solar cell **20** has a first main surface **20***a* and a second main surface **20***b*. The solar cell **20** receives light primarily on the first main surface **20***a*. As a result, the first main surface **20***a* may be referred to as the light-receiving surface, and the second main surface **20***b* may be referred to as the back surface. The solar cell **20** may generate electricity only when light is received on the first main surface **20***a* constituting the light-receiving surface, or may be a bifacial solar cell which generates electricity when light is received on both the first main surface **20***a* and the second main surface **20***b*.

[0018] There are no particular restrictions on the type of solar cell **20** that is used. The solar cells **20** can be, for example, crystalline silicon solar cells using a crystalline silicon substrate.

[0019] FIG. **2** is a simplified rear view of a solar cell **20**. As shown in FIG. **2**, the solar cell **20** has a first electrode **21** and a second electrode **22** on the second main surface **20***b* side. More specifically, the solar cell **20** has a photovoltaic conversion unit **23**, and a first electrode **21** and a second electrode **22** arranged on the main surface on the back surface side of the photovoltaic conversion unit **23**. One of the first electrode **21** or the second electrode **22** is the electrode used to collect electrons, and the other is the electrode used to collect holes.

[0020] Both the first electrode **21** and the second electrode **22** are comb-shaped. The first electrode **21** and the second electrode **22** are interdigitated. More specifically, the first electrode **21** and the second electrode **22** have a plurality of finger portions **21***a*, **22***a*, respectively. The finger portions **21***a*, **22***a* extend in one direction (the x-direction). The finger

portions **21***a*, **22***a* are interdigitated at intervals in another direction (the y-direction which is orthogonal to the one direction (the x-direction).

[0021] The finger portions **21***a* are connected electrically to a busbar portion **21***b*. The busbar portion **21***b* is arranged on one side (the x1 side) of the finger portions **21***a* in the x-direction. The busbar portion **21***b* is provided on the x1 side of the solar cell **20** in the x-direction so as to extend from one end to the other in the y-direction.

[0022] Similarly, the finger portions **22***a* are connected electrically to a busbar portion **22***b*. The busbar portion **22***b* is arranged on the other side (the x2 side) of the finger portions **22***a* in the x-direction. The busbar portion **22***b* is provided on the x2 side of the solar cell **20** in the x-direction so as to extend from one end to the other in the y-direction.

[0023] As shown in FIG. **3**, the first electrode **21** of one of two solar cells **20** adjacent to each other in the x-direction is connected electrically via a wiring member **30** to the second electrode **22** of the other solar cells **20**. More particularly, the wiring member **30** has wiring **31**. The wiring **31** has a first linear portion **31***a* which extends in the one direction (the x-direction), and a second linear portion **31***b* which also extends in the one direction (the x-direction) and is connected electrically to the first linear portion **31***a*. The first linear portion **31***a* is connected electrically to the finger portions **21***a* of the first electrode **21** of the solar cell **20** on the x2 side between the two solar cells **20** arranged adjacent to each other in the x-direction. The second linear portion **31***b* is connected electrically to the finger portions **22***a* of the second electrode **22** of the solar cell **20** on the x1 side between the two solar cells **20** arranged adjacent to each other in the x-direction.

[0024] The wiring member **30** and the solar cells **20** are bonded using an adhesive layer not shown in the drawings. The adhesive layer can be made of solder, a cured resin adhesive, or a cured resin adhesive containing a conductive material.

[0025] As shown in FIG. **2** and FIG. **3**, the width W**11** of the busbar portion **21***b* of the first electrode **21** is smaller than the width W**21** of each finger portion **21***a* of the first electrode **21**. In addition, the width W**12** of the busbar portion **22***b* of the second electrode **22** is smaller than the width W**22** of each finger portion **22***a* of the second electrode **22**.

[0026] The width W**11** of the busbar portion **21***b* is preferably no more than 0.95 times the width W**21** of each finger portion **21***a*, and more preferably from 0.95 to 0.3 times the width. Also, the width W**12** of the busbar portion **22***b* is preferably 0.95 times the width W**22** of each finger portion **22***a* or less, and more preferably from 0.95 to 0.3 times the width.

[0027] Both the first electrode **21** and the second electrode **22** include a plated film. The plated film can be made of a metal such as Cu or Sn, or an alloy containing at least one of these metals. The thickness of the plated film can be from 2 μm to 50 μm.

[0028] The plated film can be formed using electrolytic plating. When the plated film is formed using electrolytic plating, an electrode rod is first pressed against the seed layer containing the conductive material formed in the photovoltaic conversion unit **23**. The plated film is then formed by supplying electricity from the electrode rod to the seed layer in a plating solution. A thin plated film is formed where the electrode rod makes direct contact with the seed layer, forming a power supply pad (not shown in the drawing). A power supply pad is formed in both busbar portions **21***b*, **22***b*.

[0029] However, carriers such as holes and electrons are generated in the photovoltaic conversion unit **23** when the solar cell **20** is exposed to light. The carriers are collected by either the first electrode **21** or the second electrode **22**. The photovoltaic conversion efficiency of a solar cell **20** is improved by suppressing loss due to the recombination of carriers.

[0030] In order to suppress the recombination of carriers, the distance the carriers generated in the photovoltaic conversion unit **23** have to travel through the photovoltaic conversion unit **23** to be collected by the first electrode **21** or the second electrode **22** should be as short as possible. As a result, the first electrode and the second electrode require a fine pattern. For this reason, the width of the finger portions is generally minimized. However, the width of the busbar portion is usually not as small as the width of the finger portions. This is because there is a chance that the photovoltaic conversion efficiency will decline if the electrical resistance of the busbar portion collecting the carriers from the finger portions is too high. When a portion of the electrodes is composed of plated film, the plated film is believed to help keep the busbar portions from becoming as thin as the finger portions, even when several areas are formed in the busbar portions as power supply points, and the busbar portions are formed in accordance with the width of the power supply points.

[0031] However, when the busbar portions are thick, some of the carriers generated in the area of the photovoltaic conversion unit beneath the busbar portions are not collected by the busbar portions and have to travel a long distance to be collected by the electrodes. This may cause the photovoltaic conversion efficiency to decline.

[0032] In order to address this, the width W**11** of the busbar portion **21***b* of the first electrode **21** in the solar cell **20** is smaller than the width W**21** of each finger portion **21***a*. The width W**12** of the busbar portion **22***b* of the second electrode **22** is also smaller than the width W**22** of each finger portion **22***a*. This can suppress loss due to the recombination of carriers generated in the area of the photovoltaic conversion unit **23** beneath the busbar portions **21***b*, **22***b*. As a result, improved photovoltaic conversion efficiency can be realized.

[0033] From the standpoint of realizing improved photovoltaic conversion efficiency, the width W**11** of the busbar portion **21***b* is preferably 0.95 times the width W**21** of each finger portion **21***a* or less. Also, the width W**12** of the busbar portion **22***b* is preferably 0.95 times the width W**22** of each finger portion **22***a* or less. However, when the width of the busbar portions **21***b*, **22***b* is too small, problems occur related to the supply of power when forming the plated film, and plated film sometimes cannot be formed. Therefore, the width W**11**, W**12** of the busbar portions **21***b*, **22***b* is preferably 0.1 times the width W**21**, W**22** of the finger portions **21***a*, **22***a* or greater, and more preferably 0.3 times or greater.

[0034] Also, as shown in FIG. **3**, the wiring members **30** in the solar module **1** are connected to the finger portions **21***a*, **22***a*, which are thicker than the busbar portions **21***b*, **22***b*. This can suppress the decline in photovoltaic conversion efficiency caused by resistance loss in the electrodes **21**, **22** better than a situation in which the wiring members are connected electrically to the thin busbar portions. As a result, even better photovoltaic conversion efficiency can be realized.

[0035] The following is an explanation of another example of a preferred embodiment of the present invention. In the following explanation, members having substantially the

same functions as those in the first embodiment are denoted by the same reference numbers, and further explanation of these members has been omitted.

2nd Embodiment

[0036] In the explanation of the example in the first embodiment, the widths W**11**, W**12** of the busbar portions **21***b*, **22***b* of the first and second electrodes **21**, **22** were both smaller than the widths W**21**, W**22** of the finger portions **21***a*, **22***a*. However, the present invention is not limited to this configuration. In this embodiment, as shown in FIG. **4**, the width W**11** of the busbar portion **21***b* of the first electrode **21** is greater than the width W**21** of each finger portion **21***a*, and the width W**12** of the busbar portion **22***b* of the second electrode **22** is smaller than the width W**22** of each finger portion **22***a*. This embodiment is able to suppress loss due to the recombination of carriers, and can realize an improvement in photovoltaic conversion efficiency similar to that of the first embodiment.

[0037] When the width of the busbar portion is smaller than the width of each finger portion in only one of the first and second electrodes **21**, **22**, the electrode with the thinner busbar portion is preferably the electrode used to collect the majority carrier. In other words, in the present embodiment, the first electrode **21** is preferably the electrode used to collect the majority carrier. In this situation, the minority carrier generated in the area of the photovoltaic conversion unit **23** beneath the busbar portion **21***b* has to travel a shorter distance to be collected by the second electrode **22**. This can suppress loss due to the recombination of minority carriers. The resulting improvement in photovoltaic conversion efficiency is thus better than a situation in which the busbar portion of the electrode collecting the minority carrier is thinner than the finger portions and loss due to the recombination of the majority carrier is suppressed.

[0038] The present invention includes many other embodiments not described herein. Therefore, the technical scope of the present invention is defined solely by the items of the invention specified in the claims pertinent to the above explanation.

KEY TO THE DRAWINGS

[0039] **1**: Solar module
[0040] **20**: Solar cell
[0041] **21**: 1st electrode
[0042] **22**: 2nd electrode
[0043] **21***a*, **22***a*: Finger portions
[0044] **21***b*, **22***b*: Busbar portions
[0045] **23**: Photovoltaic conversion unit
[0046] **30**: Wiring member

What is claimed is:

1. A solar cell having a photovoltaic conversion unit, and a first electrode and a second electrode arranged on the same main surface of the photovoltaic conversion unit,

the first electrode having a plurality of finger portions extending in one direction, and a first busbar portion connected electrically to the plurality of first finger portions, and

the width of the first busbar portion being smaller than the width of first finger portion.

2. The solar cell according to claim **1**, wherein the width of the first busbar portion is no more than 0.95 times the width of first finger portion.

3. The solar cell according to claim **1**, wherein the first electrode is the electrode used to collect the majority carrier.

4. The solar cell according to claim **1**, wherein the first electrode includes a plated film.

5. The solar cell according to claim **1**, wherein the second electrode has a plurality of second finger portions extending in the one direction, and a second busbar portion connected electrically to the plurality of second finger portions,

the width of the second busbar portion being smaller than the width of second finger portion.

6. A solar module comprising:

a plurality of solar cells each having a photovoltaic conversion unit, and a first electrode and a second electrode arranged on the same main surface of the photovoltaic conversion unit, and

a wiring member electrically connecting the plurality of solar cells;

the first electrode having a plurality of finger portions extending in one direction, and a first busbar portion connected electrically to the plurality of first finger portions, and

the width of the first busbar portion being smaller than the width of first finger portion.

7. The solar module according to claim **6**, wherein the wiring member is connected electrically to the first electrode in the first finger portions.

* * * * *