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(54) **Title**: CDTE SOLAR BATTERY AND METHOD OF PREPARING THE SAME

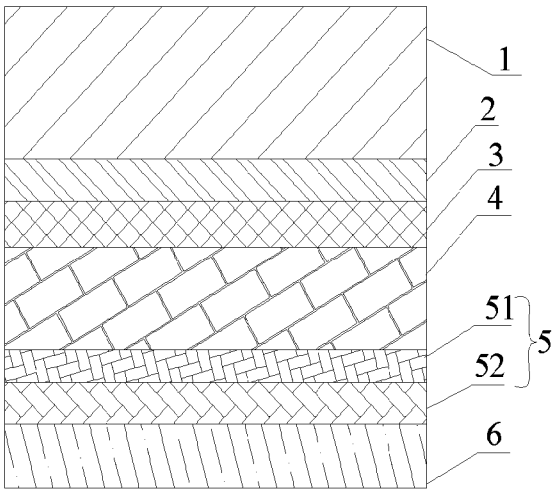

Fig. 2

(57) **Abstract**: A CdTe solar battery is provided, comprising: a back electrode layer (6); a transition layer (5) formed on the back electrode layer (6); a CdTe layer (4) formed on the transition layer (5); a CdS layer (3) formed on the CdTe layer (4); a transparent electrical conductive layer (2) formed on the 5 CdS layer (3) and a substrate (1) formed on the transparent electrical conductive layer (2). The transition layer (5) may comprise a first transition layer (51) made from ZnTe and a second transition layer (52) made from Cu 2 Te which is formed on the back electrode layer (6). A method of preparing a CdTe solar battery is also provided.

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CdTe SOLAR BATTERY AND METHOD OF PREPARING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority to and benefits of Chinese Patent Application No. 201020280813.8, filed with the State Intellectual Property Office, P. R. C. on July 29, 2010, the content of which is incorporated herein by reference in its entirety.

FIELD

The present disclosure relates to the field of compound solar battery, more particularly to a CdTe solar battery and a method of preparing the same.

BACKGROUND

CdTe is a compound semiconductor with a most suitable bandgap for photoelectric energy conversion. Solar batteries made from this semiconductor may directly convert solar energy into electric energy, and the conversion efficiency thereof is high theoretically. CdTe may be deposited easily to form a large area film while maintaining a high depositing rate. Further, the manufacturing cost of the CdTe solar battery may be reduced, and therefore compared with the silicon solar battery, the CdTe solar battery may be a new solar battery with a wide application perspective.

Normally, the structure of the CdTe solar battery may have a structure as follows. From the top down, the CdTe solar battery may comprise a glass substrate, a transparent electrical conductive layer, an n-CdS layer, a p-CdTe layer, and a back electrode layer. Metals are usually used for forming the back electrode layer, but the CdTe has high work function (5.5eV). Therefore, it may be difficult to form good ohmic contact between the metal and CdTe, thus greatly affecting the performance of the CdTe solar batteries.

Presently, for the CdTe solar battery, a transition layer may be added between the p-CdTe layer and the back electrode layer to form good ohmic contact. The structure of the solar battery is shown in Fig. 1. From the top down, the solar battery may comprise a glass substrate 1`, a transparent electrical conductive layer 2`, an n-CdS layer 3`, a p-CdTe layer 4`, a transition layer 5` and a back electrode layer 6`. The transition layer 5` may be usually a p-ZnTe layer. Although the ZnTe layer may increase the ohmic contact performance to a certain degree, the effect thereof may not meet the desired requirement. Following research shows that the transition layer may be a ZnTe: Cu layer, that is, the ZnTe layer is doped with Cu atom. The ZnTe : Cu layer may improve the ohmic contact performance of the battery, but the diffusion of Cu doping atom may lead to the reduction of the battery performance. There is still a method to prepare the ZnTe : Cu layer, that is, the ZnTe layer is usually deposited for a period of time and then doped with Cu atom. The transition layer may

improve the crystal lattice matching and the battery performance, but the doping material still exists in the transition layer in the form of an atomic state, so that the diffusion may appear after long time usage, and therefore the battery performance may be reduced.

SUMMARY

In view thereof, a CdTe solar battery may be provided, which may not lead to the reduction of the battery performance while maintaining good ohmic contact. Further, a method of preparing the CdTe solar battery is also need to be provided.

One embodiment of the present disclosure may provide a CdTe solar battery. The CdTe solar battery may comprise: a back electrode layer; a transition layer formed on the back electrode layer; a CdTe layer formed on the transition layer; a CdS layer formed on the CdTe layer; a transparent electrical conductive layer formed on the CdS layer; and a substrate formed on the transparent electrical conductive layer. The transition layer comprises: a first transition layer made from ZnTe; and a second transition layer made from Cu_2Te formed on the back electrode layer.

Another embodiment of the present disclosure may provide a method of preparing the CdTe solar battery. The method may comprise steps of: (a) forming a transparent electrical conductive layer on a substrate; (b) forming a CdS layer on the transparent electrical conductive layer; (c) forming a CdTe layer on the CdS layer; (d) forming a transition layer on the CdTe layer; and (e) forming a back electrode layer on the transition layer. The transition layer may comprise: a first transition layer made from ZnTe, and a second transition layer made from Cu_2Te which is formed on the back electrode layer.

With the CdTe solar battery and the method of preparing the same according to an embodiment of the present disclosure, not only may the short circuit current density be obviously increased by about 25%, but also the conversion efficiency of the solar battery may be increased to about 12.5%, for example. Furthermore, the performance of the CdTe solar battery according to an embodiment of the present disclosure may not be reduced but may be stable.

Additional aspects and advantages of the embodiments of the present disclosure will be given in part in the following descriptions, become apparent in part from the following descriptions, or be learned from the practice of the embodiments of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects and advantages of the disclosure will become apparent and more readily appreciated from the following descriptions taken in conjunction with the drawings, in which:

Fig. 1 is a cross-sectional view of a CdTe solar battery in prior art;

Fig. 2 is a cross-sectional view of a CdTe solar battery according to an embodiment of the present disclosure; and

Fig. 3 is a flow chart of preparing a CdTe solar battery according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

Reference will be made in detail to embodiments of the present disclosure. The embodiments described herein with reference to the accompanying drawings are explanatory and illustrative, which are used to generally understand the present disclosure. The embodiments shall not be construed to limit the present disclosure.

The CdTe solar battery according to an embodiment of the present disclosure will be described in detail with reference to Fig. 2. As shown in Fig. 2, the CdTe solar battery may comprise a substrate 1, a transparent electrical conductive layer 2, a CdS layer 3, a CdTe layer 4, a transition layer 5 and a back electrode layer 6. The transparent electrical conductive layer 2 is formed on the substrate 1, the CdS layer 3 is formed on the transparent electrical conductive layer 2. The CdTe layer 4 is formed on the CdS layer 3. The transition layer 5 is formed on the CdTe layer 4. The back electrode layer 6 is formed on the transition layer 5. As shown in Fig. 2, the transition layer 5 may comprise a first transition layer 51 made from ZnTe and a second transition layer 52 made from Cu_2Te and formed on the back electrode layer 6.

Accordingly, the transition layer in the CdTe solar battery is divided into two layers, and the second transition layer 52 may be made from Cu_2Te instead of the Cu atom, so that the diffusion of Cu_2Te may not be as serious as that of the Cu atom in the prior art. Moreover, the first transition layer made from ZnTe is disposed between the CdTe layer and the second transition layer made from Cu_2Te, so that the first transition layer made from ZnTe may efficiently prevent Cu in the second transition layer from diffusing into the CdTe layer so as to prevent the battery performance from being reduced, and good Cu doping ratio may be maintained so as to form good ohmic contact between the CdTe layer and the back electrode layer.

In addition, compared with the conventional Cu doping technology, the complex co-deposition technology may be avoided, thus simplifying the manufacturing process and increasing the finished product ratio. That is, with the CdTe solar battery according to an embodiment of the present disclosure, the cost of the transition layer may be reduced, thus reducing the producing cost of the CdTe solar battery.

With the CdTe solar battery according to an embodiment of the present disclosure, not only may the short-circuit current density be obviously increased by about 25%, but also the conversion efficiency of the solar battery may be increased to about 12.5%. Furthermore, the performance of

the CdTe solar battery according to an embodiment of the present disclosure may not be reduced but may be stable.

According to an embodiment of the present disclosure, the substrate 1 may be a glass substrate with good transparency, good heat resistance and high strength. In one embodiment, an ultra-white glass substrate may be used as the substrate 1. In another embodiment, a FTO substrate may be used as the glass substrate, and the thickness of the glass substrate may be about 1mm to 5mm.

According to an embodiment of the present disclosure, the transparent electrical conductive layer may offer good electrically conductive performance so that the electron may be easily educed. According to an embodiment of the present disclosure, the indium oxide film doped with Sn In_2O_3: Sn (ITO), ZnO:Al (ZAO), In_2O_3:Mo (IMO), or SnO_2:F (FTO) may be used as the transparent electrical conductive layer.

The CdS layer and the CdTe layer form the P-N junction of the CdTe solar battery. In one embodiment, the purity of the CdS layer and the CdTe layer may be about 99.9% and about 99.999% respectively, which may be termed as 3N and 5N in the art. In one embodiment, the thickness of the CdS layer may be about 50nm to about 300nm, and the thickness of the CdTe layer may be about 1μm to about 10μm.

The transition layer may function to increase the ohmic contact between the CdTe layer 4 and the back electrode layer 6. According to an embodiment of the present disclosure, the thickness of the transition layer 5 may be about 15nm to about 100nm. As shown in Fig. 2, the transition layer 5 is divided into two layers: the first transition layer 51 and the second transition layer 52. The first transition layer 51 is a ZnTe layer, and the second transition layer 52 is a Cu_2Te layer.

In one embodiment, the first transition layer 51 may be thicker than the second transition layer 52, so that the diffusion of Cu may be decreased, and good Cu doping ratio may also be maintained to ensure good ohmic contact between the CdTe layer 4 and the back electrode layer 6. In one embodiment, the thickness of the first transition layer 51 may be about 10nm to about 50nm, and the thickness of the second transition layer 52 may be about 5nm to about 20nm. In another embodiment, the thickness of the first transition layer 51 may be about 20nm to 30nm, and the thickness of the second transition layer 52 may be about 8nm to 15nm. The transition layer 5 may be prepared through radio frequency sputtering deposition or vacuum evaporation deposition, which will be described below.

The back electrode layer 6 may mainly function to conduct electricity. Metals with excellent electrical conductivity and small resistance, such as Au, Ag, Ni, Cu, and Mo, may be used for forming the back electrode layer 6. In one embodiment, the thickness of the back electrode layer 6 may be about 80nm to about 500nm.

In the following, a method of preparing a CdTe solar battery according to the present

disclosure as described above may be described in detail with reference to Fig. 3. As shown in Fig. 3, the method may comprises the steps of: (a) forming a transparent electrical conductive layer on a substrate (S101); (b) forming a CdS layer on the transparent electrical conductive layer (S102); (c) forming a CdTe layer on the CdS layer (S103); (d) forming a transition layer on the CdTe layer (S104); and (e) forming a back electrode layer on the transition layer (S105).

The steps will be described in detail step by step hereinafter.

S101: a transparent electrical conductive layer is formed on a substrate.

The substrate 1 may be a glass substrate with excellent transparency, good heat resistance and high strength. According to an embodiment of the present disclosure, the conductive glass with a thickness of about 1mm to about 5mm may be used as the substrate 1, and the glass substrate 1 may be pretreated at first through the following steps. The glass substrate 1 may be firstly washed with acetone for about 10min to about 60min by ultrasonic wave to remove lipids on the surface of the glass substrate 1, then washed with a cleaning agent for about 10min to about 60min by ultrasonic wave to remove inorganic contaminants on the surface of the glass substrate 1, and finally washed with deionized water for about 10min to about 60min by ultrasonic wave to remove impurities on the surface of the glass substrate 1. After the washing processes, the glass substrate 1 may be dried and then washed with plasma in a pretreatment room.

After the pretreatment step, the transparent electrical conductive layer 2 may be formed on the substrate 1. The indium oxide film doped with Sn In_2O_3:Sn (ITO), ZnO:Al (ZAO), In_2O_3:Mo (IMO), or SnO_2:F (FTO) may be used for forming the transparent electrical conductive layer 2 through target material sputtering and so on.

S102: a CdS layer is formed on the transparent electrical conductive layer.

The semi finished product obtained in the step S101 may be put into a CdS coating device, and the CdS powder with high purity is used as a sublimation source, and then the inert gas (Ar/O_2) may be introduced into the CdS coating device after the CdS coating device is vacuumized until the pressure is about 10Pa to about 200Pa. The flow rate of the inert gas may be about 1ml/min to about 20ml/min, the temperature of the sublimation source may be about 450℃ to about 700℃, and the temperature of the substrate may be about normal temperature to about 500℃. Then, coating is performed for about 1min to about 30min under the above conditions to form the CdS layer 3 with a thickness of about 50nm to about 300nm on a lower surface of the transparent electrical conductive layer 2.

S103: a CdTe layer is formed on the CdS layer.

The semi finished product obtained in the step S102 may be put into a work rest of a CdTe coating device, and the CdTe powder with high purity is used as the sublimation source. Then, the inert gas Ar may be introduced into the CdTe coating device after the CdTe coating device is

vacuumized until the pressure is about 10Pa to about 200Pa. The flow rate of the inert gas may be about 1ml/min to about 20ml/min, the temperature of the sublimation source may be about 550℃ to about 800℃, and the temperature of the substrate may be about 300℃ to about 550℃. Then, coating is performed for about 5min to about 30min under the above conditions to form the CdTe layer 4 with a thickness of about 2μm to about 5μm on a lower surface of the CdS layer 3, which may be also called as an N-type layer 3.

S104: a transition layer is formed on the CdTe layer.

As described above, the transition layer 5 may comprise a first transition layer 51 and a second transition layer 52. The first transition layer 51 may be a ZnTe layer; and the second transition layer 52 may be a Cu_2Te layer and formed on a lower surface of the first transition layer 51.

The semi finished product obtained in the step S103 may be put into a vacuum sputtering device,for example, JPGF-600A Magnetron Sputtering Coating Machine available from Beijing Beiyi Innovation Vacuum Technology Co., Ltd., and a frequency radio power source with a power of about 600W may be used. ZnTe is used as the target material and then sputtered continuously for about 1min to about 30min to form the ZnTe layer 51 on a lower surface of the CdTe layer 4. The ZnTe layer is the first transition layer 51. Alternatively, the thickness of the first transition layer 51 may be about 10nm to about 100nm.

The semi finished product obtained in the above step may be put into an vacuum sputtering equipment, for example, JPGF-600A Magnetron Sputtering Coating Machine available from Beijing Beiyi Innovation Vacuum Technology Co., Ltd., and a frequency radio power source with a power of about 200W may be used. Cu_2Te is used as the target material and then sputtered continuously for about 1min to about 30min to form the Cu_2Te layer 52 on a lower surface of the ZnTe layer 51. The Cu_2Te layer is the second transition layer 52. Alternatively, the thickness of the second transition layer 52 may be about 10nm to about 100nm.

S105: a back electrode layer is formed on the transition layer.

The semi finished product obtained in step S104 may be put into a vacuum sputtering equipment (for example, JPGF-600A Magnetron Sputtering Coating Machine available from Beijing Beiyi Innovation Vacuum Technology Co., Ltd.). The target material may be at least one material selected from the group consisting of Mo, Ni, Cu, Ag, and combinations thereof, then a metal electrode layer with a thickness of about 50nm to about 300nm is formed by sputtering, and the metal electrode layer is the back electrode layer 6. After the step S105 is finished, the CdTe solar battery according to an embodiment of the present disclosure may be obtained.

The transition layer may be divided into two layers according to the above method, and the second transition layer 52 may be made from Cu_2Te instead of the Cu atom, so that the diffusion of Cu_2Te may not be as serious as that of the Cu atom in the prior art. Moreover, the first ZnTe

transition layer 51 is disposed between the CdTe layer 4 and the Cu_2Te layer 52, so that the first ZnTe transition layer 51 may efficiently prevent Cu in the second transition layer 52 from diffusing into the CdTe layer 4 so as to prevent the battery performance from being reduced, and good Cu doping ratio may be maintained so as to form good ohmic contact between the CdTe layer and the back electrode layer.

The method for preparing the CdTe solar battery according to an embodiment of the present disclosure may be simple in process, and the deposition equipment may also be a conventional one, so that complex treatment processes may be avoided and the producing cost may be reduced accordingly.

In the following, particular embodiments of the present disclosure will be described in detail. These embodiments should not be construed to limit the scope of the present disclosure in any way.

Embodiment 1

In this embodiment, a CdTe solar battery comprises a glass substrate 1, a transparent electrical conductive layer 2, a CdS layer 3, a CdTe layer 4, a transition layer 5 and a back electrode layer 6 stacked in turn. An ultra-white glass substrate with a thickness of about 2mm is used as the glass substrate 1. The transparent electrical conductive layer 2 is a FTO substrate with a thickness of about 1μm. The CdS layer 3 has a thickness of about 200nm, and the CdS powder used as the sublimation source has a purity of at least about 99.999% or 5N. The CdTe layer has a thickness of about 5μm, and the CdTe powder used as the sublimation source has a purity of at least about 99.999% or 5N.

In this embodiment, the transition layer 5 comprises a first ZnTe transition layer 51 and a second Cu_2Te transition layer 52. The first transition layer 51 with a thickness of about 25nm was deposited on the CdTe layer 4, and the second transition layer 52 with a thickness of about 10nm was deposited on the first transition layer 51. The back electrode layer 6 was made from Ni, and the thickness of the back electrode layer 6 was about 200nm.

In this embodiment, the CdTe solar battery was obtained through the following steps.

(a) The conductive glass with a thickness of about 2mm was used as the substrate 1. Then, the glass substrate was firstly washed with acetone for about 30min by ultrasonic wave to remove lipids on the surface of the glass substrate, then washed with a cleaning agent for about 20min by ultrasonic wave to remove inorganic contaminants on the surface of the glass substrate, and finally washed with deionized water for about 30min by ultrasonic wave to remove impurities on the surface of the glass substrate. After the washing processes, the glass substrate 1 was dried and then washed with plasma in a pretreatment room.

(b) The transparent electrical conductive layer 2 was formed on the glass substrate 1, and

SnO_2:F (FTO) was used as the target material for preparing the transparent electrical conductive layer 2 through target material sputtering method.

(c) The semi finished product obtained in the above steps was put into a CdS coating device, and the CdS powder with a purity of at least about 99.9% was used as the sublimation source, and then the inert gas (Ar/O_2) was introduced into the CdS coating device after the CdS coating device was vacuumized until the pressure was about 100Pa. The flow rate of the inert gas was about 10ml/min, the temperature of the sublimation source was about 450℃, and the temperature of the substrate was about 300℃. Coating was performed for about 25min under the above conditions to form the CdS layer 3 with a thickness of about 50nm to about 300nm on a lower surface of the transparent electrical conductive layer 2.

(d) The semi finished product obtained in the above steps was put into a work rest of a CdTe coating device, and the CdTe powder with a purity of at least about 99.999% or 5N was used as the sublimation source. The inert gas Ar was introduced into the CdTe coating device after the CdTe coating device was vacuumized until the pressure was about 100Pa, the flow rate of the inert gas was about 15ml/min, the temperature of the sublimation source was about 600℃, and the temperature of the substrate was about 350℃. Coating was performed for about 25min under the above conditions to form the CdTe layer 4 with a thickness of about 5μm on a lower surface of the CdS layer 3.

(e) The semi finished product obtained in the above steps was put into a vacuum sputtering equipment, for example, JPGF-600A Magnetron Sputtering Coating Machine available from Beijing Beiyi Innovation Vacuum Technology Co., Ltd., and a frequency radio power source with a power of about 600W was used. ZnTe was used as the target material and then sputtered continuously for about 20min to form the ZnTe layer 51 on a lower surface of the CdTe layer 4. The ZnTe layer was the first transition layer 51. Alternatively, the thickness of the first transition layer 51 was about 25nm.

The semi finished product obtained in the above steps was put into a vacuum sputtering equipment, for example, JPGF-600A Magnetron Sputtering Coating Machine available from Beijing Beiyi Innovation Vacuum Technology Co., Ltd., and a frequency radio power source with a power of about 200W was used. Cu_2Te was used as the target material and then sputtered continuously for about 20min to form the Cu_2Te layer 52 on a lower surface of the ZnTe layer 51. The Cu_2Te layer was the second transition layer 52. Alternatively, the thickness of the second transition layer 52 was about 10nm.

(f) The semi finished product obtained in the above steps was put into the vacuum sputtering equipment, for example, JPGF-600A Magnetron Sputtering Coating Machine available from Beijing Beiyi Innovation Vacuum Technology Co., Ltd.), and Ni was used as the target material and

then sputtered to form the metal electrode layer with a thickness of about 200nm. The metal electrode layer was the back electrode layer 6. After the sputtering was finished, the CdTe solar battery S1 was obtained.

Embodiment 2

This embodiment is substantially the same as Embodiment 1, except that: the thickness of the first transition layer is about 50nm, and the thickness of the second transition layer is about 20nm. Then, the CdTe solar battery S2 is obtained.

Embodiment 3

This embodiment is substantially the same as Embodiment 1, except that the following:

The thickness of the first transition layer is about 13nm, and the thickness of the second transition layer is about 6nm. Then, the CdTe solar battery S3 is obtained.

Embodiment 4

This embodiment is substantially the same as Embodiment 1, except that the following:

The thickness of the first transition layer is about 30nm, and the thickness of the second transition layer is about 15nm. Then, the CdTe solar battery S4 is obtained.

Embodiment 5

This embodiment is substantially the same as Embodiment 1, except that the following:

The thickness of the first transition layer is about 20nm, and the thickness of the second transition layer is about 8nm. Then, the CdTe solar battery S5 is obtained.

Comparative Embodiment 1

This embodiment is substantially the same as Embodiment 1, except that the following:

The transition layer 5 is the ZnTe : Cu layer with a thickness of about 50nm. Then, the CdTe solar battery C1 is obtained.

Performance Test

The CdTe solar batteries obtained according to Embodiments 1 to 5 and Comparative Embodiment 1 were tested on a pulse solar simulator (PSS8) and a digital display controller according to the standard IEC 61646:2008 (Thin-Film terrestrial photovoltaic (PV) modules-design qualification and type approval) respectively. From the obtained I-V (current to voltage) curve, the open circuit voltage, the short circuit current, the photoelectrical conversion efficiency and the fill

factor are obtained, and the results are shown in Table 1.

Table 1

CdTe Solar Battery	Open Circuit Voltage	Short Circuit Current	Fill Factor	Photoelectrical Conversion Efficiency
S1	830mV	20.7mA	76.80%	14.80%
S2	840mV	20.5mA	75.40%	13.90%
S3	795mV	20.8mA	73.18%	12.20%
S4	825mV	20.6mA	75.70%	14.10%
S5	835mV	20.4mA	76.20%	14.00%
C1	795mV	20.8mA	73.18%	12.00%

As shown in the Table 1, compared with Comparative Embodiment 1, the CdTe solar batteries obtained according to Embodiments 1 to 5 may have higher open circuit voltage, lower short circuit current, higher photoelectrical conversion efficiency and higher fill factor, which shows that the battery comprising the transition layer according to an embodiment of the present disclosure may have improved battery performance, and therefore the transition layer may efficiently prevent the performance from being damaged while maintaining excellent ohmic contact.

Although explanatory embodiments have been shown and described, it would be appreciated by those skilled in the art that changes, alternatives, and modifications all falling into the scope of the claims and their equivalents may be made in the embodiments without departing from spirit and principles of the disclosure.

WHAT IS CLAIMED IS:

1. A CdTe solar battery, comprising:

a back electrode layer;

a transition layer formed on the back electrode layer;

a CdTe layer formed on the transition layer;

a CdS layer formed on the CdTe layer;

a transparent electrical conductive layer formed on the CdS layer; and

a substrate formed on the transparent electrical conductive layer, wherein the transition layer comprises:

a first transition layer made from ZnTe; and

a second transition layer made from Cu_2Te formed on the back electrode layer.

2. The CdTe solar battery according to claim 1, wherein the first transition layer is thicker than the second transition layer.

3. The CdTe solar battery according to claim 1, wherein the thickness of the transition layer is about 15nm to about 100nm.

4. The CdTe solar battery according to claim 2, wherein the thickness of the first transition layer is about 10nm to about 50nm, and the thickness of the second transition layer is about 5nm to about 20nm.

5. The CdTe solar battery according to claim 4, wherein the thickness of the first transition layer is about 20nm to about 30nm, and the thickness of the second transition layer is about 8nm to about 15nm.

6. The CdTe solar battery according to claim 1, wherein the thickness of the substrate is about 1mm to about 5mm;

the thickness of the transparent electrical conductive layer is about 1μm to about 10μm;

the thickness of the CdS layer is about 50nm to about 300nm;

the thickness of the CdTe layer is about 1μm to about 10μm; and

the thickness of the back electrode layer is about 80nm to about 500nm.

7. A method of preparing a CdTe solar battery, comprising steps of:

(a) forming a transparent electrical conductive layer on a substrate;

(b) forming a CdS layer on the transparent electrical conductive layer;

(c) forming a CdTe layer on the CdS layer;

(d) forming a transition layer on the CdTe layer; and

(e) forming a back electrode layer on the transition layer, wherein

the transition layer comprises:

a first transition layer made from ZnTe; and

a second transition layer made from Cu_2Te which is formed on the back electrode layer.

8. The method according to claim 7, wherein the step of forming the transition layer further comprises steps of:

depositing the first transition layer made from ZnTe on the CdTe layer; and

depositing the second transition layer made from Cu_2Te on the first transition layer.

9. The method according to claim 8, wherein the first transition layer is deposited by a thickness larger than that of the second transition layer.

10. The method according to claim 8, wherein the thickness of the transition layer by depositing is about 15nm to about 100nm.

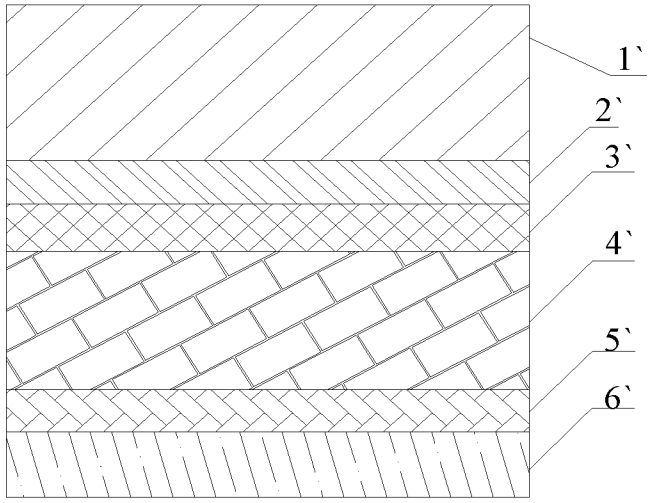

Fig. 1

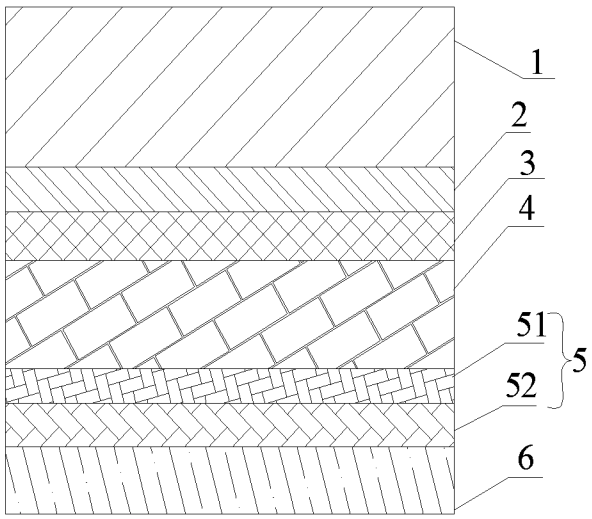

Fig. 2

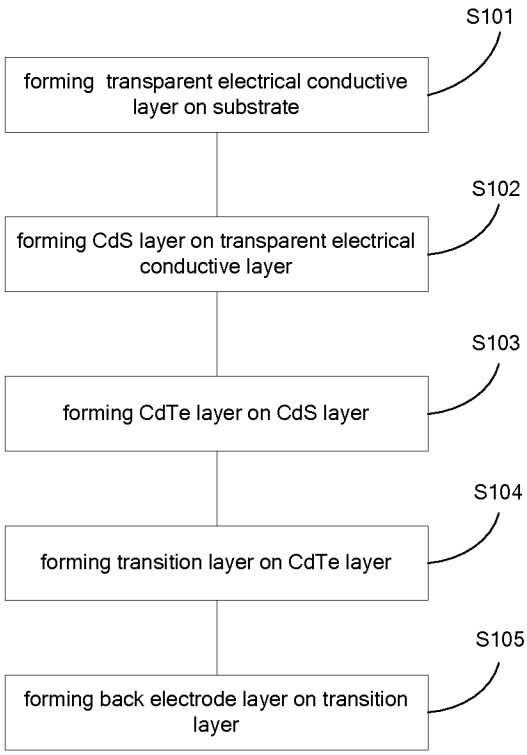
S101
forming transparent electrical conductive layer on substrate
S102
forming CdS layer on transparent electrical conductive layer
S103
forming CdTe layer on CdS layer
S104
forming transition layer on CdTe layer
S105
forming back electrode layer on transition layer

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/077766

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: H01L31/-; C25D7/12

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

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

EPODOC,DWPI,CPRSABS,CNABS,CNKI: solar, cell, photovoltaic, battery, CdTe, CdS, Cu2Te,CuxTe,ZnTe

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 201780976 U (BYD CO. LTD.) 30 Mar. 2011 (30.03.2011) Claims 1-10, paragraphs 29-38 of description, figure 2	1-10
X	WO 2009/117072 A1 (SOLEXANT CORP.) 24 Sep. 2009 (24.09.2009) Paragraphs 13,15, 27, 37, 48, 54, 56, 58, 64 of description, figures 5,11	1-10
A	CN 101267007 A (UNIV SICHUAN) 17 Sep. 2008 (17.09.2008) The whole document	1-10

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 Oct. 2011 (08.10.2011)	**03 Nov. 2011 (03.11.2011)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer HUANG,Daoxu Telephone No. (86-10)62411845

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2011/077766

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 201780976 U	30.03.2011	NONE	
WO 2009/117072 A1	24.09.2009	CA2716687 A1	24.09.2009
		AU2009226128 A1	24.09.2009
		JP2011515852 A	19.05.2011
		KR20100125288 A	30.11.2010
		US2009235986 A1	24.09.2009
		US2010229931 A1	16.09.2010
		EP2268855 A1	05.01.2011
		CN101978101 A	16.02.2011
		US7858872 B2	28.12.2010
		US2011061737 A1	17.03.2011
		IN201005483 P4	01.04.2011
CN 101267007 A	17.09.2008	CN100573922 C	23.12.2009

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/077766

A. CLASSIFICATION OF SUBJECT MATTER

H01L 31/04（2006.01）i
H01L 31/0224 (2006.01) n