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(71) Applicant (for all designated States except US): **LG INNOTEK CO., LTD.** [KR/KR]; Seoul Square, 541, Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **LEE, In Jae** [KR/KR]; Seoul Square, 541, Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR). **PARK, Jin Gyeong** [KR/KR]; Seoul Square, 541, Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR). **KIM, Sang Gon** [KR/KR]; Seoul Square, 541, Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR). **KIM, Soon Gil** [KR/KR]; Seoul Square, 541, Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR). **EOM, Jun Phil** [KR/KR]; Seoul Square, 541, Namdaemunno 5-ga, Jung-gu, Seoul 100-714 (KR).

(74) Agent: **SEO, Kyo Jun**; 9th Fl. Hyun Juk Bldg., 832-41, Yeoksam-dong, Gangnam-gu, Seoul 135-080 (KR).

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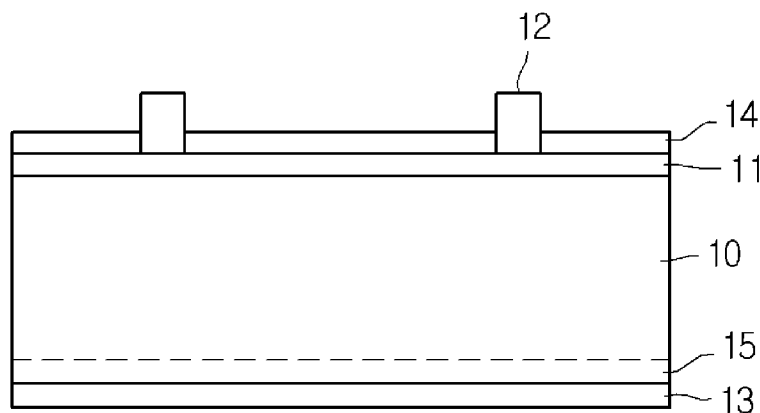
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(54) Title: SOLAR CELL AND PASTE COMPOSITION FOR THE SAME

[Fig. 1]



(57) Abstract: A paste composition for an electrode of a solar cell according to the embodiment includes a phosphorous-containing dispersing agent. The phosphorous-containing dispersing agent includes at least one selected from the group consisting of an amphiphilic polymeric dispersing agent, an acidic polymeric dispersing agent, a basic polymeric dispersing agent, a neutral polymeric dispersing agent, a cationic dispersing agent, and an anionic dispersing agent.



Description

Title of Invention: SOLAR CELL AND PASTE COMPOSITION FOR THE SAME

Technical Field

- [1] The disclosure relates to a solar cell and a paste composition for the same.

Background Art

- [2] Recently, the development of next generation clean energy has become more important due to the lack of fossil fuel. Among the next generation clean energy, a solar cell is spotlighted as an energy source for solving the future energy problem because it rarely causes environmental pollution and has the semi-permanent life span and there exists infinite resources for the solar cell.
- [3] Such a solar cell can be manufactured by forming a front electrode and a rear electrode on a silicon substrate having an N type semiconductor and a P type semiconductor. In the solar cell, it is very important to improve the photoelectronic transformation efficiency. In order to improve the photoelectronic transformation efficiency, there has been suggested a method of controlling doping density in the N type semiconductor and the P type semiconductor, and a method of improving the characteristic of top and the rear electrodes.

Disclosure of Invention

Technical Problem

- [4] The embodiment provides a solar cell and a paste composition for an electrode of the solar cell, capable of improving the efficiency of the solar cell.

Solution to Problem

- [5] A paste composition for an electrode of a solar cell according to the embodiment includes a phosphorous-containing dispersing agent.
- [6] The phosphorous-containing dispersing agent may include at least one selected from the group consisting of an amphiphilic polymeric dispersing agent, an acidic polymeric dispersing agent, a basic polymeric dispersing agent, a neutral polymeric dispersing agent, a cationic dispersing agent, and an anionic dispersing agent.
- [7] The phosphorous-containing dispersing agent may include phosphoric ester salt having a metal-affinitive group.
- [8] The amount of the phosphorous-containing dispersing agent may be 0.1 to 10 wt% based on a total amount of the paste composition.
- [9] The paste composition includes a metal powder, a glass frit and an organic vehicle, and the organic vehicle may include the phosphorous-containing dispersing agent.
- [10] The paste composition may further include an additive, and the paste composition

includes 60 to 95 wt% of the metal powder, 0.3 to 15 wt% of the glass frit, 4 to 39 wt% of the organic vehicle, and 0.1 to 10 wt% of the additive.

[11] The paste composition may include a metal powder, a glass frit, an organic vehicle, and an additive, and the additive may include the phosphorous-containing dispersing agent.

[12] The paste composition may include 60 to 95 wt% of the metal powder, 0.3 to 15 wt% of the glass frit, 4 to 39 wt% of the organic vehicle, and 0.1 to 10 wt% of the additive.

[13] The metal powder may include a silver powder or an aluminum powder.

[14] A solar cell according to the embodiment may include an electrode manufactured by using the paste composition.

Advantageous Effects of Invention

[15] The paste composition according to the embodiment may include a phosphorous-containing dispersing agent so that the dispersing characteristic of the paste composition can be improved. Therefore, the content of metal powder in the paste composition can be increased so that the electric and mechanical characteristics of the electrode manufactured by using the paste composition can be improved. As a result, the efficiency of the solar cell including the electrode manufactured by using the paste composition can be improved.

[16] In addition, stability of the paste composition can be enhanced due to the phosphorous-containing dispersing agent, so that the productivity and reliability of the electrode can be improved.

Brief Description of Drawings

[17] FIG. 1 is a sectional view of a solar cell.

Best Mode for Carrying out the Invention

[18] Hereinafter, a paste composition and a solar cell including an electrode manufactured by using the paste composition according to the embodiment will be described in detail.

[19] The paste composition for the electrode of the solar cell includes metal powder, a glass frit, and an organic vehicle. The paste composition may further include an additive. In addition, the paste composition includes a phosphorus-based dispersing agent, which is included in the organic vehicle or the additive.

[20] The metal powder may include silver powder or aluminum powder having light weight and superior conductivity. The paste composition including the silver powder can be used for manufacturing the front electrode and the paste composition including the aluminum powder can be used for manufacturing the rear electrode, but the embodiment is not limited thereto.

[21] The metal powder may have a spherical shape, a plate shape, a bell shape or a flake

shape. The metal powder may consist of particles having the same shape or different shapes.

- [22] The mean grain size of the metal powder is about 1.5 to 10. If the mean grain size is less than 1.5, the organic substance may not penetrate into the metal powder due to the agglomeration of the metal powder so that the metal powder may not be easily dispersed. In addition, if the mean grain size exceeds 10, many pores are formed in the metal powder, so the density of the metal powder is lowered and electric resistance of the electrode is increased.
- [23] Various materials can be used for the glass frit. For instance, lead borosilicate glass having the softening point of 400 to 600, lead silicate glass, bismuth glass or lithium glass can be used as the glass frit. In more detail, the glass frit may include at least one or two selected from the group consisting of Bi_2O_3 , B_2O_3 , SiO_2 , Al_2O_3 , CdO , CaO , BaO , ZnO , Na_2O , Li_2O , PbO , and ZrO . If the glass frit includes $\text{PbO-Bi}_2\text{O}_3\text{-B}_2\text{O}_3\text{-ZnO-SiO}_2$, the bowing of the substrate formed with the electrode can be prevented. For instance, the bowing of the substrate can be prevented even if the electrode has a thin thickness of about 15 to 25. In addition, the glass frit has the grain size of about 1 to 10.
- [24] The organic vehicle allows the paste composition to have viscosity and rheological property adapted to be coated on the substrate.
- [25] The organic vehicle may include a solvent and a polymer dissolved in the solvent. In addition, the organic vehicle may include a thixotropic agent, a leveling agent, and an anti-foaming agent. The organic vehicle may also include the phosphorous-containing dispersing agent, which will be described later in detail.
- [26] The polymer may include acrylate resin, ethylcellulous, nitrocellulous, polymer of ethylcellulous and phenol resin, wood rosin, and polymethacrylate of alcohol. Preferably, ethylcellulous is used as the polymer.
- [27] The solvent may include at least one or two selected from the group consisting of butylcarbitolacetate, butylcarbitol, butylcellosolve, butylcellosolveacetate, propyleneglycolmonomethylether, dipropyleneglycolmonomethylether, propyleneglycolmonomethylpropionate, ethyletherpropionate, terpeneol, propyleneglycolmonomethyletheracetate, dimethylamino, formaldehyde, methylethylketone, gamma-butyrolactone, ethyllactate, and texanol. Preferably, butylcarbitolacetate is used as the solvent.
- [28] The thixotropic agent may include urea type, amide type or urethane type polymer/organic substance or inorganic silica.
- [29] The paste composition according to the embodiment may further include various additives to improve the desired characteristics thereof. For instance, the paste composition may further include sintering additive, thickener, stabilizer, or surfactant. In

addition, the paste composition may include the phosphorous-containing dispersing agent, which will be described later in detail.

- [30] For instance, the paste composition may include 60 to 95 wt% of the metal powder, 0.3 to 15 wt% of the glass frit, 4 to 39 wt% of the organic vehicle, and 0.1 to 10 wt% of the additive.
- [31] If the amount of the metal powder exceeds 95 wt%, the composition may not be prepared in the form of paste. If the amount of the metal powder is less than 60 wt%, the amount of conductive material is reduced, so that the resistance of the rear electrode may be increased. That is, when the solar cell has the above composition ratio, sinterability of the paste composition can be improved and the efficiency of the solar cell can be improved.
- [32] If the amount of the glass frit is in the range of 0.3 to 15 wt%, adhesive property, sinterability and characteristics of the post-process of the solar cell can be improved.
- [33] If the amount of the organic vehicle exceeds 39 wt%, the amount of the metal powder is reduced, so that the resistance of the electrode may be increased, thereby degrading the efficiency of the solar cell. In addition, if the amount of the organic vehicle is less than 4 wt%, the metal powder may not be easily mixed and distributed. In this case, the metal powder may not be easily coated on the substrate. As a result, the precision of patterns of the electrode formed by using the paste composition may be degraded.
- [34] If the amount of the additive exceeds 10 wt%, the amount of the metal powder is reduced, so that the resistance of the rear electrode may be increased, thereby degrading the efficiency of the solar cell. In addition, if the amount of the additive is less than 0.1 wt%, the effect derived from the additive may be degraded.
- [35] The paste composition according to the embodiment includes the phosphorous-containing dispersing agent included in the organic vehicle and/or the additive. That is, the phosphorous-containing dispersing agent can be included in the organic vehicle of the paste composition and/or the phosphorous-containing dispersing agent can be included in the paste composition separately from the organic vehicle.
- [36] The phosphorous-containing dispersing agent strongly adsorbs on the surface of the metal powder to improve the dispersing property of the paste composition. Thus, the phosphorous-containing dispersing agent can prevent agglomeration of the metal powder when the paste composition is prepared. Therefore, the content of the metal powder in the paste composition can be increased so that the electric and mechanical characteristics of the electrode manufactured by using the paste composition according to the embodiment can be improved. As a result, the efficiency of the solar cell including the electrode manufactured by using the paste composition can be improved. Since the mechanical characteristic of the solar cell can be improved, the bowing of

the silicon substrate of the solar cell can be prevented.

- [37] In addition, stability of the paste composition can be enhanced due to the phosphorous-containing dispersing agent, so that the paste composition can be prevented from being deformed when preparing the paste composition. Accordingly, productivity can be improved when manufacturing the electrode by using the paste composition and reliability of the electrode can be improved.
- [38] The phosphorous-containing dispersing agent may include copolymer having a high molecular weight. For instance, the phosphorous-containing dispersing agent may include phosphoric ester salt having a metal-affinitive group. Since the phosphorous-containing dispersing agent includes the metal-affinitive group as well as phosphorous strongly adsorbed onto the metal powder, the agglomeration of the metal powder can be more effectively prevented.
- [39] The phosphorous-containing dispersing agent may be classified into an amphiphilic polymeric dispersing agent, an acidic polymeric dispersing agent, a basic polymeric dispersing agent, a neutral polymeric dispersing agent, a cationic dispersing agent, and an anionic dispersing agent according to the type of the metal-affinitive group. If the amphiphilic polymeric dispersing agent is employed as the phosphorous-containing dispersing agent, productivity of the paste composition can be more improved.
- [40] For instance, the amphiphilic polymeric dispersing agent may include metal-affinitive groups of carboxylic acid type, sulfonic acid type, sulfate type, phosphoric acid type or phosphoric ester type based on an anionic active moiety groups of hydrophilic moieties. In addition, the amphiphilic polymeric dispersing agent may include metal-affinitive groups of betaine type, imidazoline type, -alanine type, or amino type. These metal-affinitive groups can be included in the main chain of phosphoric ester salt or attached as functional groups.
- [41] In addition, the acidic polymeric dispersing agent may include metal-affinitive groups having a carboxylic acid group, a sulfonic acid group, a sulfate group, a phosphoric ester group, etc., as an acidic group. These metal-affinitive groups can be included in the main chain of phosphoric ester salt or attached as functional groups.
- [42] The cationic dispersing agent may include metal-affinitive groups of aliphatic amine salt and quaternary ammonium salt, aliphatic quaternary ammonium salt, and heterocyclic quaternary ammonium salt thereof. These metal-affinitive groups can be included in the main chain of phosphoric ester salt or attached as functional groups.
- [43] The neutral dispersing agent may be a block copolymer including metal-affinitive groups of ether type, ester ether type, ester type or nitrogen-containing type. The ether type metal-affinitive group may include a block copolymer including alkyl and alkyl aryl polyoxyethylene ether, alkyl aryl formaldehyde-condensated polyoxyethylene ether, polyoxypropylene, etc., as an oleophilic group. The ester ether type metal-affinitive

group may include polyoxyethyleneether of glycerinester, polyoxyethyleneether of sorbitanester, polyoxyethyleneether of sorbitolester, etc. The ester type metal-affinitive group may include polyethyleneglycolfattyacidester, glycerinester, sorbitanester, propyleneglycolester, sugarester, etc. The nitrogen-containing metal-affinitive group may include fatty acid alkanolamide, polyoxyethylenefattyacidamid, polyoxyethylenalkylamine, amineoxide, etc.

[44] The amount of the phosphorous-containing dispersing agent is about 0.1 to 10 wt% based on the total amount of the paste composition. If the amount of the phosphorous-containing dispersing agent exceeds 10 wt%, carbon may remain after the firing process and the excessive phosphorous-containing dispersing agent may increase the viscosity of the paste composition so that the paste composition may not be easily controlled during the process. If the amount of the phosphorous-containing dispersing agent is less than 0.1 wt%, the dispersing effect is insufficient.

[45] The above elements are uniformly mixed with each other in a predetermined ratio by using a blender or a 3-axis roll, thereby preparing the paste composition. When measured by using a Brookfield HBT viscometer and a multi-purpose cup using a #51 spindle under 5rpm and 25, the paste composition may have viscosity of about 50 to 200PaS.

[46] Hereinafter, an example of the solar cell employing the paste composition according to the embodiment will be described with reference to FIG. 1. FIG. 1 is a sectional view showing the solar cell.

[47] Referring to FIG. 1, the solar cell includes a P type silicon substrate 10 provided on the top surface thereof with an N type semiconductor 11, a front electrode 12 electrically connected to the N type semiconductor 11 and a rear electrode 13 electrically connected to the P type silicon substrate 10. An anti-reflective layer 14 can be formed on the top surface of the emitter 11 except for an area where the front electrode 12 is formed. In addition, a BSF (back surface field) layer 15 is formed on the rear electrode 13 of the silicon substrate 10.

[48] The paste composition according to the embodiment can be used to form the front electrode 12 or the rear electrode 13 of the solar cell. That is, the front electrode 12 or the rear electrode 13 can be manufactured by drying and firing the paste composition coated on the silicon substrate 10. For instance, the paste composition including the silver powder can be used for manufacturing the front electrode 12 and the paste composition including the aluminum powder can be used for manufacturing the rear electrode 13, but the embodiment is not limited thereto.

[49] In detail, the electrode of the solar cell can be formed by drying and firing the paste composition coated on the silicon substrate 10.

[50] The paste composition can be coated on the silicon substrate 10 through the painting

scheme. In more detail, the screen painting scheme can be employed to coat the paste composition on the silicon substrate. The paste composition can be coated with a thickness of about 20 to 60 through the painting scheme. Details of this are disclosed in Korean Laid-open Patent Publication Nos. 10-2006-0108550 and 10-2006-0127813 and Japanese Laid-open Patent Publication Nos. 2001-202822 and 2003-133567, the contents of which are herein incorporated by reference in their entirety.

[51] The drying process is performed under the temperature of 90 to 250° and the firing process is performed under the temperature of 600 to 950°. Preferably, the high-temperature/high-speed firing process is performed for 5 seconds to 1 minute at the temperature of about 800 to 900°.

[52] The paste composition according to the embodiment can improve dispersing property of the metal powder, so that the content of the metal powder can be increased. Thus, the front electrode 12 or the rear electrode 13 manufactured by using the paste composition may have superior electric and mechanical characteristics. In addition, the paste composition can be stably stored, so that the stability and reliability of the front electrode 12 or the rear electrode 13 manufactured by using the paste composition can be improved.

[53] Hereinafter, the experimental examples and the comparative example of the embodiment will be described in detail. These examples are illustrative purposes only, and the embodiment is not limited thereto.

[54]

[55] Example 1

[56] The paste composition was prepared by mixing 80g of metal powder with 5g of glass frit, 15g of organic vehicle, and 1g of phosphorous-containing dispersing agent. Silver powder was used as the metal powder, and the glass frit was $\text{PbO-Bi}_2\text{O}_3\text{-B}_2\text{O}_3\text{-ZnO-SiO}_2$. The organic vehicle was prepared by adding 10 wt% of polymer, which was prepared by mixing two types of ethyl cellulose having molecular weights different from each other in a ratio of 3:1, to 90 wt% of solution, which was prepared by mixing butylcarbitolacetate with terpineol in a ratio of 50:50. The amphiphilic polymeric dispersing agent was used as the phosphorous-containing dispersing agent. Phosphoric ester salt of copolymer having a high molecular weight with a metal-affinitive group was used as the amphiphilic polymeric dispersing agent.

[57]

[58] Example 2

[59] Example 2 is similar to Example 1 except that the acidic dispersing agent was used as the phosphorous-containing dispersing agent. The acidic dispersing agent was a copolymer having an acidic group including phosphorous.

[60]

[61] Example 3

[62] Example 3 is similar to Example 1 except that the cationic dispersing agent was used as the phosphorous-containing dispersing agent. The cationic dispersing agent was alkylol ammonium salt having multi-functional polymer including phosphorous.

[63]

[64] Example 4

[65] Example 4 is similar to Example 1 except that the neutral dispersing agent was used as the phosphorous-containing dispersing agent. The neutral dispersing agent was a block copolymer having a metal-affinitive group and including phosphorous.

[66]

[67] Comparative Example

[68] The paste composition was prepared similarly to Example 1 except that the phosphorous-free dispersing agent was used instead of the phosphorous-containing dispersing agent. The phosphorous-free dispersing agent was a block copolymer having a high molecular weight with a metal-affinitive group.

[69] The paste composition of Examples 1 to 4 and Comparative Example was printed on the silicon substrate through the silk screen printing process and then the firing process was performed to manufacture the front electrode. The result of efficiency of the solar cell having the front electrode is shown in Table 1.

[70] The efficiency of the solar cell was measured by using a solar simulator.

[71] Table 1

[Table 1]

[Table]

	Efficiency (%)
Example 1	17.07
Example 2	16.77
Example 3	16.56
Example 4	16.66
Comparative Example	16.37

[72] As can be understood from Table 1, Examples 1 to 4 represent superior efficiencies as compared with the efficiency of the Comparative Example. In detail, the minimum efficiency of Examples 1 to 4 is 16.56% and the mean efficiency of Examples 1 to 4 is 16.77%, but the efficiency of the Comparative Example is 16.37%. In the solar cell industrial field, the efficiency grade is classified in the unit of 0.2%, so the efficiency increment of 0.2% may have serious meaning. That is, Examples 1 to 4 represent excellent efficiencies.

[73] Although a preferred embodiment of the present invention has been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

Industrial Applicability

[74] The embodiments are applicable to the electrode of the solar cell.

[75]

[76]

Claims

- [Claim 1] A paste composition for an electrode of a solar cell, comprising a phosphorous-containing dispersing agent.
- [Claim 2] The paste composition of claim 1, wherein the phosphorous-containing dispersing agent includes at least one selected from the group consisting of an amphiphilic polymeric dispersing agent, an acidic polymeric dispersing agent, a basic polymeric dispersing agent, a neutral polymeric dispersing agent, a cationic dispersing agent, and an anionic dispersing agent.
- [Claim 3] The paste composition of claim 1, wherein the phosphorous-containing dispersing agent includes phosphoric ester salt having a metal-affinitive group.
- [Claim 4] The paste composition of claim 1, wherein an amount of the phosphorous-containing dispersing agent is 0.1 to 10 wt% based on a total amount of the paste composition.
- [Claim 5] The paste composition of claim 1, wherein the paste composition includes a metal powder, a glass frit and an organic vehicle, and the organic vehicle includes the phosphorous-containing dispersing agent.
- [Claim 6] The paste composition of claim 5, further comprising an additive, wherein the paste composition includes 60 to 95 wt% of the metal powder, 0.3 to 15 wt% of the glass frit, 4 to 39 wt% of the organic vehicle, and 0.1 to 10 wt% of the additive.
- [Claim 7] The paste composition of claim 1, wherein the paste composition includes a metal powder, a glass frit, an organic vehicle, and an additive, and the additive includes the phosphorous-containing dispersing agent.
- [Claim 8] The paste composition of claim 7, wherein the paste composition includes 60 to 95 wt% of the metal powder, 0.3 to 15 wt% of the glass frit, 4 to 39 wt% of the organic vehicle, and 0.1 to 10 wt% of the additive.
- [Claim 9] The paste composition of claim 1, wherein the metal powder includes a silver powder or an aluminum powder.
- [Claim 10] A solar cell including an electrode manufactured by using the paste composition of claim 1.

[Fig. 1]

