A changeover from the belt conveyor system to the walking beam conveyor system enables a space saving of a unit necessary for cooling to produce a rapid heating/rapid cooling firing profile suitable to form a satisfactory BSF layer, and offers the advantages of reduced power consumption and shorter treating time. This method, however, inevitably suffers from degradations of performance and manufacture yield of solar cell devices since the substrate comes in direct contact with wires as well.

Citation List

Patent Document

[0012]

Patent Document 1: JP-A H08-162446

Patent Document 2: JP-A 2009-238991

SUMMARY OF INVENTION

Technical Problem

[0013]

~~An object~~Embodiments of the invention, which has been made under the above-mentioned circumstances, ~~is~~ seek to provide a furnace for firing solar cell device electrodes, which ensures effective firing of conductive paste to form an electrode on a substrate by preventing a metal component in the conductive paste from building up on transport members such as wires to cause damages to the electrode or substrate and by minimizing firing variations within the substrate plane, and thus may enable~~s~~ to manufacture a solar cell device in high yields without any loss of solar cell performance; a method for manufacturing a solar cell device using the firing furnace; and a solar cell device.

Solution to Problem

[0014]

Making extensive investigations to attain the above object, the inventors have found that when a furnace for firing solar cell device electrodes, comprising a transport member for transporting a substrate having a conductive paste applied thereto, a heating zone for heating the substrate to fire the conductive paste, and a cooling zone for cooling the heated substrate is used, and particularly when the transport member is of wire structure, and the wire transport member is heated by a heating means, so that the temperature of the transport member may approach to the temperature of the heating zone atmosphere during firing of the electrode paste, the substrate can be effectively heated. This can prevents a metal component in the conductive paste from remaining on the wire after melting, thus prevents the buildup of the metal component from causing damages to the electrode or substrate, and minimizes firing variations within the substrate plane. It is then possible to fire the electrode paste in the manufacture of a solar cell device without any losses of solar cell performance and yield. ~~The invention is predicated on these findings.~~

[0015]

Accordingly, embodiments of the invention provides a firing furnace, a method for manufacturing a solar cell device, and a solar cell device, as defined below.

~~(1)~~ According to a first aspect of the present invention, there is provided ~~A~~ a furnace for firing electrodes on a solar cell device, comprising a transport member for transporting a substrate having a conductive paste applied thereto by moving while holding the substrate in contact with portions of the substrate applied with the paste, a heating zone for heating the substrate with the transport member to fire the conductive paste, and a cooling zone for cooling the heated substrate, the furnace further comprising ~~a~~ means for preheating the transport member, so that the temperature difference between the heating zone atmosphere and the transport member is 0 to 20°C.

~~(2)~~ In ~~The~~ the firing furnace as disclosed, ~~of (1) wherein~~ the temperature difference between the heating zone atmosphere and the transport member ~~is~~ may be 0 to 200°C.

~~(3)~~ In ~~The~~ the firing furnace as disclosed, ~~of (1) or (2) wherein~~ the transport member may comprise~~s~~ at least two wires extended for parallel and horizontal motion in a longitudinal direction of the furnace wherein the substrate is transported by the wires while it is rested thereon.

~~(4)~~ In ~~The~~ the firing furnace as disclosed, ~~of any one of (1) to (3) wherein~~ the transport member ~~is~~ may be of the walking beam system.

~~(5)~~ In ~~The~~ the firing furnace as disclosed, ~~of any one of (1) to (4) wherein~~ the means for heating the transport member ~~is~~ may be an electrical means.

~~(6)~~ According to a second aspect of the present invention, there is provided ~~A~~a method for manufacturing a solar cell device, comprising the steps of forming a pn junction in a semiconductor substrate, applying a conductive paste to a light-receiving surface and non-light-receiving surface of the semiconductor substrate, and firing the conductive paste to form power-extracting electrodes,

the step of firing the conductive paste being performed in the firing furnace as defined in the first aspect ~~of any one of (1) to (5)~~.

~~(7)~~ There is also disclosed ~~A~~a solar cell device obtained by the method as defined in the second aspect~~of (6)~~.

Advantageous Effects of Invention

[0016]

Embodiments of ~~The~~the invention intend~~s~~ that the wire temperature approach to the temperature of the heating zone atmosphere or the temperature of aluminum paste layer, particularly when a wire firing furnace is used in the firing of electrode paste. The wire is heated at a temperature about 50°C higher than the normal temperature so that the wire

temperature is substantially equal to the temperature of the heating zone atmosphere, prior to firing. This may prevents a lowering of yield by damaging of the electrode by the buildup on wires of

the metal component in the conductive paste, and may enables continuous operation of the wire firing furnace. This may further minimizes firing variations within the substrate plane which are otherwise caused by the lower temperature of the wire, thus suppressing any loss of performance. Also the furnace may provides a high throughput as compared with mesh belt firing furnaces and the like.

BRIEF DESCRIPTION OF DRAWINGS

[0017]

FIG. 1 is a schematic cross-sectional view showing the structure of a typical solar cell device.

FIG. 2 is a schematic view of an exemplary mesh belt firing furnace.

FIG. 3 is a schematic view of one exemplary wire type firing furnace.

FIG. 4 is a schematic view of one exemplary wire type walking beam firing furnace.

FIG. 5 is a partial enlarged view of fixed and movable beams in the wire type walking beam firing furnace.

FIG. 6 is a schematic cross-sectional view of a movable beam having a substrate rested thereon.

DESCRIPTION OF EMBODIMENTS

[0018]

Embodiments of the invention are described below in detail. However, the scope of the invention is not limited to the illustrated embodiments because the invention can be implemented in a wide variety of embodiments in addition to the illustrated embodiments. The drawings are not depicted to scale. Certain members are depicted in enlarged scale in order to clarify the description and understanding of the invention whereas insignificant parts are not depicted.