SUMMARY OF INVENTION

PROBLEM TO BE SOLVED BY INVENTION

[0007]

However, the aluminum oxide film has poor fire-through capability during electrode formation, as compared with the silicon nitride film and the like, so that the electric resistance between the electrode and the silicon substrate may be increased, failing to provide satisfactory solar cell characteristics. Then, when an electrode is formed on a silicon substrate having an aluminum oxide film formed thereon, the film must be configured to a pattern conformal to the electrode pattern. This pattern configuration is generally carried out by patterning using photolithography or acid resist, or by etching the film with acid. A technique of printing an etching paste and a patterning technique based on laser ablation are also included. These techniques, however, are scarcely acceptable in the commercial application from the standpoint of cost because not only the number of steps is increased, but also the materials and equipment involved are very expensive.

On the other hand, in order to maximize the passivation function of the aluminum oxide film, heat treatment around 400° C is necessary. This further complicates the solar cell manufacturing process, becoming a barrier against cost reduction. Furthermore, common conductive pastes of high-temperature cure type are difficult to fire through the aluminum oxide film, resulting in increased electric resistance and restricting the solar cell characteristics.

[0008]

Embodiments~~An object~~ of the present invention~~, which is devised in view of the above discussed circumstances, is~~ seek to provide a solar cell having good fire-through capability to an aluminum oxide film, high productivity, low cost, and high efficiency, a method of manufacturing the solar cell, and a solar cell module.

MEANS FOR SOLVING PROBLEM

[0009]

Making extensive investigations to attain the above object, the inventors have arrived at the invention which relates to a solar cell comprising a semiconductor substrate having a light-receiving surface and a non-light-receiving surface, a pn junction formed in the semiconductor substrate, a passivation layer disposed on the light-receiving surface and/or the non-light-receiving surface, and power extraction electrodes disposed on the light-receiving surface and the non-light-receiving surface. A layer including an aluminum oxide film having a thickness of up to 40 nm is formed as the passivation layer, which provides for a fire-through capability during electrode formation. A solar cell having satisfactory characteristics is thus obtainable.

[0010]

~~Specifically, the present invention provides a solar cell, a method of manufacturing the same, and a solar cell module, as defined below.~~

~~Claim 1.~~

~~——~~According to a first aspect of the present invention, there is provided a~~A~~ solar cell comprising a semiconductor substrate having a light-receiving surface and a non-lighting-receiving surface, a pn junction formed in the semiconductor substrate, a passivation layer disposed on the light-receiving surface and/or the non-light-receiving surface, and power extraction electrodes disposed on the light-receiving surface and the non-light-receiving surface, wherein

said passivation layer includes an aluminum oxide film having a thickness of up to 40 nm.

~~Claim 2.~~

The~~The solar cell of claim 1 wherein said~~ passivation layer may be~~is~~ disposed on the non-light-receiving surface of a p-type semiconductor substrate or the light-receiving surface of an n-type semiconductor substrate.

~~Claim 3.~~

The ~~solar cell of claim 1 or 2 wherein said~~ passivation layer may includes the aluminum oxide film and

another dielectric film disposed thereon, the other dielectric film being formed of silicon oxide, titanium oxide, silicon carbide or tin oxide.

~~Claim 4:~~

The ~~solar cell of any one of claims 1 to 3 wherein said~~ electrode may be~~is~~ a sintered product obtained by firing a conductive paste, and the sintered product may penetrate~~s~~ through the passivation layer including the aluminum oxide film so as to make electrical contact between the electrode and the substrate.

~~Claim 5:~~

The ~~solar cell of claim 4 wherein said~~ sintered product may contain~~s~~ an oxide of one or more elements selected from the group consisting of B, Na, Al, K, Ca, Si, V, Zn, Zr, Cd, Sn, Ba, Ta, Tl, Pb, and Bi.

~~Claim 6:~~

The ~~solar cell of claim 4 or 5 wherein said~~ aluminum oxide film may have~~has~~ a built-in negative electric charge which may be~~is~~ increased by the firing step.

~~Claim 7:~~

A~~The solar cell of any one of claims 4 to 6 wherein a~~ region of the~~said~~ aluminum oxide film which is to be disposed immediately below the electrode may be~~is~~ displaced by the penetration of the sintered product, and the~~said~~ aluminum oxide film may be~~is~~ present in at least a portion of the region excluding the region disposed immediately below the electrode.

~~Claim 8:~~

According to a second aspect of the present invention, there is provided a solar cell module comprising a plurality of electrically connected solar cells as defined in the first aspect.~~set forth in any one of claims 1 to 7.~~

~~Claim 9:~~

According to a third aspect of the present invention, there is provided a method for manufacturing a solar cell, comprising the steps of forming a pn junction in a semiconductor substrate, forming a passivation layer on a light-receiving surface and/or a non-light-receiving surface of the semiconductor substrate, and forming power extraction electrodes on the light-receiving surface and the non-light-receiving surface,

wherein an aluminum oxide film having a thickness of up to 40 nm is formed as the passivation layer.

~~Claim 10:~~

The ~~method of claim 9 wherein the~~ electrode may be~~is~~ formed by firing a conductive paste at 500 to 900°C for 1 second to 30 minutes to form a sintered product that penetrates through the passivation layer to make electrical contact between the electrode and the substrate.

~~Claim 11:~~

The ~~method of claim 10 wherein said~~ sintered product may contain~~s~~ an oxide of one or more elements selected from the group consisting of B, Na, Al, K, Ca, Si, V, Zn, Zr, Cd, Sn, Ba, Ta, Tl, Pb, and Bi.

~~Claim 12:~~

The ~~method of claim 10 or 11 wherein said~~ aluminum oxide film may have~~has~~ a built-in negative electric charge which is increased by the firing step.

ADVANTAGEOUS EFFECTS OF INVENTION

[0011]

Now that an aluminum oxide film having a specific thickness is formed on a substrate surface, specifically the non-light-receiving surface of a p-type semiconductor substrate or the light-receiving surface of a n-type semiconductor substrate, a satisfactory passivation function and tight electrical contact between the substrate and the electrode may be~~are~~ obtainable merely by the step of firing a conductive paste, which is a prior art technique. Embodiments of t~~T~~he invention can omit~~s~~ the anneal step which is necessary in the prior art for the aluminum oxide film to exert a passivation effect, and can be~~is~~ very effective for cost reduction.

BRIEF DESCRIPTION OF DRAWINGS

[0012]

FIG. 1 is a cross-sectional view of an exemplary prior art solar cell structure.