face field layer") **30** formed at or adjacent to a second surface (hereinafter, referred to as "a back surface") of the semiconductor substrate **10**. Also, the electrodes **24** and **34** may include a first electrode (or a plurality of first electrodes) (hereinafter, referred to as "a first electrode") **24** electrically connected to the emitter layer **20**, and a second electrode (or a plurality of second electrodes) (hereinafter, referred to as "a second electrode") **34** electrically connected to the semiconductor substrate **10** or the back surface field layer **30**. In addition, the solar cell **100** may further include an anti-reflection layer **22** and a passivation layer **32**. This will be described in more detail.

The semiconductor substrate **10** may include one or more of various semiconductor materials. For example, the semiconductor substrate **10** includes silicon having a dopant of the second conductivity type. Single crystal silicon or polycrystalline silicon may be used for the silicon, and the second conductivity type may be an n-type. That is, the semiconductor substrate **10** may include single crystal silicon or polycrystalline silicon having a group V element, such as phosphorus (P), arsenic (As), bismuth (Bi), antimony (Sb), or the like.

When the semiconductor substrate **10** has the n-type dopant as in the above, the emitter layer **20** of a p-type is formed at the front surface of the semiconductor substrate **10**, and thereby forming a p-n junction. When the sun light is incident to the p-n junction, the electrons generated by the photoelectric effect moves to the back surface of the semiconductor substrate **10** and are collected by the second electrode **34**, and the holes generated by the photoelectric effect moves to the front surface of the semiconductor substrate **10** and are collected by the first electrode **24**. Then, the electric energy is generated.

Here, the holes having mobility lower than that of the electrodes move to the front surface of the semiconductor substrate **10**, and not the back surface of the semiconductor substrate **10**. Therefore, the conversion efficiency of the solar cell **100** can be enhanced.

Although it is not shown, the front and/or back surfaces of the semiconductor substrate **10** may be a textured surface to have protruded and/or depressed portions of various shapes (such as pyramid shape). Thus, the surface roughness is increased by the protruded and/or depressed portions, and reflectance of the incident sun light at the front surface of the semiconductor substrate **10** can be reduced by the texturing. Then, an amount of the light reaching the p-n junction between the semiconductor substrate **10** and the emitter layer **20** can increase, thereby reducing an optical loss of the solar cell **100**. However, the invention is not limited thereto, and thus, the protruded and/or depressed portions may be formed only at the front surface, or there may be no protruded and/or depressed portions at the front and back surfaces.

The emitter layer **20** of the first conductive type may be formed at the front surface of the semiconductor substrate **10**. Here, the emitter layer **20** may include a first dopant **202** of the first conductive type and a first counter dopant **204** of the second conductive type opposite to the first conductive type.

A p-type dopant such as a group III element (for example, boron (B), aluminum (Al), gallium (Ga), indium (In) or the like) may be used for the first dopant **202**. A n-type dopant such as a group V element (for example, phosphorus (P), arsenic (As), bismuth (Bi), antimony (Sb), or the like) may be used for the first counter dopant **204**. However, the invention is not limited thereto, and thus, the first dopant **202** and the first counter dopant **204** may be formed of one or more of various elements or materials.

In the embodiment, the emitter layer **20** as the dopant layer includes the first counter dopant **204**, along with the first dopant **202**. Accordingly, a sufficient junction depth can be achieved, and the recombination velocity can be reduced by decreasing the surface concentration of the emitter layer **20**. More particularly, when the surface concentration of the emitter layer **20** decreases and a shallow emitter is achieved, the current density can be increased. However, if the doping amount of the first dopant **20** is decreased in order to achieve the shallow emitter, the junction depth is not sufficient. Therefore, in the embodiment, the sufficient junction depth can be achieved by doping a lot of the first dopant **202**, and the shallow emitter can be achieved by reducing the surface concentration of the emitter layer **20** through doping the first counter dopant **204** having a conductive type different from the first dopant **202**.

That is, in the embodiment, the recombination velocity can be reduced by the shallow emitter and the sufficient junction depth can be achieved. As a result, efficiency of the solar cell **100** can be enhanced.

For example, the emitter layer **20** may have sheet resistance of about 50~150 ohm/square (ohm/□), and may have a thickness of about 0.3~1.5 μm (for example, 0.5~1.2 μm). However, the invention is not limited thereto. Thus, the sheet resistance and the thickness of the emitter layer **20** may be changed.

Here, a doping concentration of the first counter dopant **204** is less than a doping concentration of the first dopant **202**, and the emitter layer **20** has the first conductive type. For example, the ratio of the doping concentration of the first counter dopant **204**: the doping concentration of the first dopant **202** may be about 1:3 to 1:30. When the ratio is above 1:30, the reduction of the surface concentration due to the first counter dopant **204** may be small. When the ratio is below 1:3, the property of the emitter layer **20** may be deteriorated. Here, when the doping concentration of the first counter dopant **204**: the ratio of the doping concentration of the first dopant **202** is about 1:5 to 1:15, the first counter dopant **204** has a great effect.

The concentration difference between the first counter dopant **204** and the first dopant **202** may originate in a doping amount difference between the first counter dopant **204** and the first dopant **202**. In this case, the doping amount of the first counter dopant **204** and the first dopant **202** can be detected by secondary ion mass spectroscopy (SIMS) and so on. In the embodiment, the emitter layer **20** includes the first counter dopant **204**, and thus, the concentration of the elements of the second conductive type at the emitter layer **20** is larger than that at a portion of the semiconductor substrate **10** where the emitter layer **20** and the back surface field layer **30** are not formed.

The anti-reflection layer **22** and the first electrode **24** may be formed on the emitter layer **20** at the front surface of the semiconductor substrate **10**.

The anti-reflection layer **22** may be substantially at the entire front surface of the semiconductor substrate **10**, except for the portion where the first electrode **24** is formed. The anti-reflection layer **22** reduces reflectance (or reflectivity) of sun light incident to the front surface of the semiconductor substrate **10**. Thus, an amount of the sun light reaching the p-n junction formed between the semiconductor substrate **10** and the emitter layer **20** can be increased, thereby increasing short circuit current (Isc) of the solar cell **100**.

Also, the anti-reflection layer **22** passivates defects at a surface or a bulk of the emitter layer **20**. Thus, the defects at the emitter layer **20** are passivated, and recombination sites of minority carrier are reduced or eliminated, thereby increasing