Gaseous Ozone (O_3) Treatment for Solar Cell Fabrication

TECHNICAL FIELD

[0001] Embodiments of the present invention are in the field of renewable energy and, in particular, methods of fabricating solar cells and apparatuses for fabricating solar cells.

BACKGROUND

[0002] Photovoltaic cells, commonly known as solar cells, are well known devices for direct conversion of solar radiation into electrical energy. Generally, solar cells are fabricated on a semiconductor wafer or substrate using semiconductor processing techniques to form a p-n junction near a surface of the substrate. Solar radiation impinging on the surface of, and entering into, the substrate creates electron and hole pairs in the bulk of the substrate. The electron and hole pairs migrate to p-doped and n-doped regions in the substrate, thereby generating a voltage differential between the doped regions. The doped regions are connected to conductive regions on the solar cell to direct an electrical current from the cell to an external circuit coupled thereto

[0003] Efficiency is an important characteristic of a solar cell as it is directly related to the capability of the solar cell to generate power. Likewise, efficiency in producing solar cells is directly related to the cost effectiveness of such solar cells. Accordingly, techniques for increasing the efficiency of solar cells, or techniques for increasing the efficiency in the manufacture of solar cells, are generally desirable. Embodiments of the present invention allow for increased solar cell efficiency and increased solar cell manufacture efficiency by providing novel processes and apparatuses for fabricating solar cell structures.

SUMMARY

[0003a] According to a first aspect of the invention, there is provided a method of fabricating a solar cell, the method comprising: treating a light-receiving surface of a substrate with a gaseous ozone (O_3) process; and, subsequently, texturizing the light-receiving surface of the substrate, wherein treating the light-receiving surface of the substrate with the gaseous ozone process comprises flowing a stream of ozone gas across the light-receiving surface of the substrate and ~~removing at least a portion of~~ breaking down an organic residue to fragments which are of a size that does not substantially impact the texturing, disposed on the light-receiving surface of the substrate according to the equation:

$$O_3\ (g) + \text{organic residue}\ (s) \rightarrow O_2\ (g) + \text{oxidized organic species}\ (g).$$

[0003b] According to a second aspect of the invention, there is provided a method of fabricating a solar cell, the method comprising: treating a light-receiving surface of a substrate with a gaseous ozone (O_3) process, the gaseous ozone process comprises flowing a stream of ozone gas across the light-receiving surface of the substrate; and, subsequently, treating the light-receiving surface using an aqueous potassium hydroxide (KOH) solution having a weight percent approximately in the range of 20 – 45, at a temperature approximately in the range of 60 – 85 degrees Celsius, for a duration approximately in the range of 60 – 120 seconds; and, subsequently, texturizing the light-receiving surface of the substrate and at least a portion of a surface of the substrate opposite the light-receiving surface, the texturizing comprising treating the substrate with an aqueous alkaline process; and, subsequently, forming a back-contact solar cell from the substrate by forming contacts on the surface of the substrate opposite the light-receiving surface. The treating the light-receiving surface of the substrate with the gaseous ozone process includes breaking down an organic residue to fragments which are of a size that does not substantially impact the texturing, disposed on the light-receiving surface of the substrate. The removing the portion of the organic residue includes oxidizing the organic residue according to the equation:

$$O_3\,(g) + \text{organic residue}\,(s) \rightarrow O_2\,(g) + \text{oxidized organic species}\,(g).$$

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Figure 1 illustrates two texturization processes: (a) a conventional process and (b) a process including an initial ozone gas treatment, in accordance with an embodiment of the present invention.

[0005] Figure 2A illustrates a cross-sectional view of an operation including treating a light-receiving surface of a substrate with a gaseous ozone (O_3) process in a

CLAIMS

What is claimed is:

1. A method of fabricating a solar cell, the method comprising:

treating a light-receiving surface of a substrate with a gaseous ozone (O_3) process; and, subsequently,

texturizing the light-receiving surface of the substrate, wherein treating the light-receiving surface of the substrate with the gaseous ozone process comprises flowing a stream of ozone gas across the light-receiving surface of the substrate and ~~removing~~ breaking down ~~at least a portion of~~ an organic residue to fragments which are of a size that does not substantially impact the texturing, disposed on the light-receiving surface of the substrate according to the equation:

O_3 (g) + organic residue (s) → O_2 (g) + oxidized organic species (g).

2. The method of claim 1, wherein flowing the stream of ozone gas comprises maintaining the substrate at a temperature approximately in the range of 15 – 40 degrees Celsius and flowing for a duration approximately in the range of 1 – 3 minutes.

3. The method of claim 1, wherein texturizing the light-receiving surface of the substrate comprises treating the light-receiving surface with an aqueous alkaline process.

4. The method of claim 3, wherein the aqueous alkaline process comprises wet etching the light-receiving surface using an aqueous potassium hydroxide (KOH) solution of approximately 2 weight percent, at a temperature approximately in the range of 50 – 85 degrees Celsius, for a duration approximately in the range of 10 – 20 minutes.

5. The method of claim 4, further comprising:

subsequent to treating the light-receiving surface of the substrate with the gaseous ozone process and prior to texturizing the light-receiving surface of the substrate, treating the light-receiving surface using an aqueous potassium hydroxide (KOH) solution having a weight percent approximately in the range of 20 – 45, at a temperature approximately in the range of 60 – 85 degrees Celsius, for a duration approximately in the range of 60 – 120 seconds.

6. The method of claim 4, wherein texturizing the light-receiving surface of the substrate is performed immediately following treating the light-receiving surface of the substrate with the gaseous ozone process.

7. The method of claim 1, further comprising:

subsequent to texturizing the light-receiving surface of the substrate, forming a back-contact solar cell from the substrate, wherein texturizing the light-receiving surface of the substrate further comprises texturizing at least a portion of a surface of the substrate opposite the light-receiving surface.

8. A method of fabricating a solar cell, the method comprising:

treating a light-receiving surface of a substrate with a gaseous ozone (O_3) process, the gaseous ozone process comprises flowing a stream of ozone gas across the light-receiving surface of the substrate; and, subsequently,

treating the light-receiving surface using an aqueous potassium hydroxide (KOH) solution having a weight percent approximately in the range of 20 – 45, at a temperature approximately in the range of 60 – 85 degrees Celsius, for a duration approximately in the range of 60 – 120 seconds; and, subsequently,

texturizing the light-receiving surface of the substrate and at least a portion of a surface of the substrate opposite the light-receiving surface, the texturizing comprising treating the substrate with an aqueous alkaline process; and, subsequently,

forming a back-contact solar cell from the substrate by forming contacts on the surface of the substrate opposite the light-receiving surface.

wherein treating the light-receiving surface of the substrate with the gaseous ozone process comprises breaking down an organic residue to fragments which are of a size that does not impact the texturing, disposed on the light-receiving surface of the substrate, and

wherein removing the portion of the organic residue comprises oxidizing the organic residue according to the equation:

O_3 (g) + organic residue (s) → O_2 (g) + oxidized organic species (g).

9. The method of claim 8, wherein flowing the stream of ozone gas comprises maintaining the substrate at a temperature approximately in the range of 15 – 40 degrees Celsius and flowing for a duration approximately in the range of 1 – 3 minutes.

~~10. The method of claim 8, wherein treating the light-receiving surface of the substrate with the gaseous ozone process comprises removing at least a portion of an organic residue disposed on the light-receiving surface of the substrate.~~

~~11. The method of claim 10, wherein removing the portion of the organic residue comprises oxidizing the organic residue according to the equation:~~

~~O_3 (g) + organic residue (s) → O_2 (g) + oxidized organic species (g).~~

~~12~~10. The method of claim 8, wherein the aqueous alkaline process comprises wet etching the substrate using an aqueous potassium hydroxide (KOH) solution of approximately 2 weight percent, at a temperature approximately in the range of 50 – 85 degrees Celsius, for a duration approximately in the range of 10 – 20 minutes.