PASSIVATION OF LIGHT-RECEIVING SURFACES OF SOLAR CELLS WITH HIGH ENERGY GAP (EG) MATERIALS

TECHNICAL FIELD

[0001] Embodiments of the present disclosure are in the field of renewable energy and, in particular, methods of passivating light-receiving surfaces of solar cells with high energy gap (Eg) materials, and the resulting 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. Some embodiments of the present disclosure allow for increased solar cell manufacture efficiency by providing novel processes for fabricating solar cell structures. Some embodiments of the present disclosure allow for increased solar cell efficiency by providing novel solar cell structures as well as improved stability by eliminating common degradation modes.

SUMMARY

[0003a] In one aspect, there is provided a solar cell comprising:
a substrate having a light-receiving surface; a passivating dielectric layer disposed on the light-receiving surface of the substrate; and a Group III-nitride material layer disposed above the passivating dielectric layer and an interfacial layer disposed directly between the passivating

dielectric layer and the Group III-nitride material layer, the interfacial layer comprising a material different from the passivating dielectric layer and different from the Group III-nitride material.

[0003b] In another aspect, there is provided a solar cell, comprising:
a crystalline silicon substrate having a light-receiving surface;
a Group III-nitride material layer disposed above the light-receiving surface of the crystalline silicon substrate; and an anti-reflective coating (ARC) layer disposed on the Group III-nitride material layer, the ARC layer comprising a material different from the Group III-nitride material layer, wherein the Group III-nitride material layer is disposed on the light-receiving surface of the crystalline silicon substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Figures 1A-1E illustrate cross-sectional views of various stages in the fabrication of a solar cell, in accordance with an embodiment of the present disclosure, wherein:

[0005] Figure 1A illustrates a starting substrate of a solar cell;

CLAIMS

What is claimed is:

1. A solar cell, comprising:

a substrate having a light-receiving surface;

a passivating dielectric layer disposed on the light-receiving surface of the substrate; and

a Group III-nitride material layer disposed above the passivating dielectric layer; and

an interfacial layer disposed directly between the passivating dielectric layer and the Group III-nitride material layer, the interfacial layer comprising a material different from the passivating dielectric layer and different from the Group III-nitride material layer.

2. The solar cell of claim 1, wherein the interfacial layer is a silicon-rich amorphous silicon layer and has a thickness approximately in the range of 30 – 50 Angstroms.

3. The solar cell of claim 1, wherein the interfacial layer is a silicon-based layer with no oxygen, the layer selected from the group consisting of silicon-rich amorphous silicon, intrinsic or phosphorus doped amorphous silicon, and polycrystalline silicon, and wherein the silicon-based layer has a thickness approximately in the range 10-200 Angstroms.

4. The solar cell of claim 1, wherein the Group III-nitride material layer is disposed on the passivating dielectric layer.

5. The solar cell of claim 1, wherein the Group III-nitride material layer is selected from the group consisting of an aluminum nitride (AlN) layer, an aluminum gallium nitride ($Al_xGa_{1-x}N$, where $0 < x < 1$) layer, and a gallium nitride (GaN) layer.

6. The solar cell of claim 1, further comprising:

an anti-reflective coating (ARC) layer disposed on the Group III-nitride material layer, the ARC layer comprising a material different from the Group III-nitride material layer.

7. The solar cell of claim 6, wherein the ARC layer is a layer selected from the group consisting of an aluminum oxide (AlO_x, x is equal to or less than 1.5) layer and a silicon oxynitride (SiO_yN_z, $y > 0$, $z > 0$) layer, and wherein the ARC layer and the Group III-nitride material layer together form a dual layer anti-reflective coating for the solar cell.

8. The solar cell of claim 7, wherein the Group III-nitride material layer has a thickness approximately in the range of 50 – 900 Angstroms and has an index of refraction of approximately 2.0-2.4, and wherein the ARC layer has a thickness approximately in the range of 300 – 1500 Angstroms and has an index of refraction of approximately 1.8.

9. The solar cell of claim 8, wherein the Group III-nitride material layer and the ARC layer together provide current enhancement and stability for the solar cell.

10. The solar cell of claim 6, wherein the ARC layer is a layer of hydrogenated silicon nitride (SiN:H).

11. The solar cell of claim 10, wherein the Group III-nitride material layer has a thickness approximately in the range of 30 – 100 Angstroms and has an index of refraction of approximately 2.0-2.4, and wherein the layer of SiN:H has a thickness of approximately 700 Angstroms and has an index of refraction greater than approximately 1.9.

12. The solar cell of claim 11, wherein the Group III-nitride material layer and the ARC layer together provide stability for the solar cell while the high band gap material provides passivation with no absorption of the photogenerating spectrum.

13. The solar cell of claim 1, wherein the substrate is a crystalline silicon substrate, and the passivating dielectric layer is a layer of silicon dioxide (SiO_2) having a thickness approximately in the range of 10-300 Angstroms.

14. The solar cell of claim 1, wherein the light-receiving surface has a texturized topography, and wherein both the passivating dielectric layer and the Group III-nitride material layer are conformal with the texturized topography of the light-receiving surface.

15. The solar cell of claim 1, wherein the substrate further comprises a back surface opposite the light-receiving surface, the solar cell further comprising:

a plurality of alternating N-type and P-type semiconductor regions at or above the back surface of the substrate; and

a conductive contact structure electrically connected to the plurality of alternating N-type and P-type semiconductor regions.

16. A solar cell, comprising:

a substrate having a light-receiving surface;

a passivating dielectric layer disposed on the light-receiving surface of the substrate;

a large direct band gap material layer disposed above the passivating dielectric layer, the large direct band gap material layer having an energy gap (Eg) of at least approximately 3.3eV; an anti-reflective coating (ARC) layer disposed on the large direct band gap material layer, the ARC layer comprising a material different from the large direct band gap material layer; and

an interfacial layer disposed directly between the passivating dielectric layer and the large direct band gap material layer, the interfacial layer comprising a material different from the passivating dielectric layer and different from the large direct band gap material layer.

17. A solar cell, comprising:

a crystalline silicon substrate having a light-receiving surface;

a passivating dielectric layer disposed on the light-receiving surface of the substrate;

a Group III-nitride material layer disposed above the passivating dielectric layer;

an anti-reflective coating (ARC) layer disposed on the Group III-nitride material layer, the ARC layer comprising a material different from the Group III-nitride material layer; and an interfacial layer disposed directly between the passivating dielectric layer and the Group III-nitride material layer, the interfacial layer comprising a material different from the passivating dielectric layer and different from the large direct band gap material layer.

18. The solar cell of claim 17, wherein the Group III-nitride material layer is disposed on the light-receiving surface of the crystalline silicon substrate.