SINGLE P-N JUNCTION TANDEM PHOTOVOLTAIC DEVICE

CROSS REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority to U.S. Provisional Patent Application Ser. No. 60/945,281, entitled "Single P-N Junction Tandem Photovoltaics," filed on Jun. 20, 2007, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The disclosure relates to solar cells are more particularly to a single junction tandem solar cell.

[0004] 2. Background Discussion

[0005] Solar or photovoltaic cells are semiconductor devices having P-N junctions which directly convert radiant energy of sunlight into electrical energy. Conversion of sunlight into electrical energy involves three major processes: absorption of sunlight into the semiconductor material; generation and separation of positive and negative charges creating a voltage in the solar cell; and collection and transfer of the electrical charges through terminals connected to the semiconductor material. A single depletion region for charge separation typically exists in the P-N junction of each solar cell.

[0006] Current traditional solar cells based on single semiconductor material have an intrinsic efficiency limit of approximately 31%. A primary reason for this limit is that no one material has been found that can perfectly match the broad ranges of solar radiation, which has a usable energy in the photon range of approximately 0.4 to 4 eV. Light with energy below the bandgap of the semiconductor will not be absorbed and converted to electrical power. Light with energy above the bandgap will be absorbed, but electron-hole pairs that are created quickly lose their excess energy above the bandgap in the form of heat. Thus, this energy is not available for conversion to electrical power.

[0007] Higher efficiencies have been attempted to be achieved by using stacks of solar cells with different band gaps, thereby forming a series of solar cells, referred to as "multijunction," "cascade," or "tandem" solar cells. Tandem solar cells are the most efficient solar cells currently available. Tandem cells are made by connecting a plurality (e.g., two, three, four, etc.) P-N junction solar cells in series. Tandem cells are typically formed using higher gap materials in the top cell to convert higher energy photons, while allowing lower energy photons to pass down to lower gap materials in the stack of solar cells. The bandgaps of the solar cells in the stack are chosen to maximize the efficiency of solar energy conversion, where tunnel junctions are used to series-connect the cells such that the voltages of the cells sum together. Such multijunction solar cells require numerous layers of materials to be formed in a complex, stacked arrangement.

SUMMARY

[0008] In accordance with one or more embodiments, a single P-N junction solar cell is provided having multiple regions for charge separation while allowing the electrons and holes to recombine such that the voltages associated with both depletion regions of the solar cell will add together. In one or more embodiments, the conduction band edge (CBE) of a top layer in the solar cell is formed to line up with the valence band edge (VBE) of a lower layer in the solar cell.

[0009] In accordance with one or more embodiments, a solar cell is provided having an alloy of either InGaN or InAlN formed on one side of the P-N junction with Si formed on the other side in order to produce characteristics of a two junction (2J) tandem solar cell through a single P-N junction. In one embodiment, an $In_{1-x}Ga_xN$ alloy is utilized, while in another embodiment $In_{1-x}Al_xN$ is utilized. A single P-N junction solar cell formed in accordance with one or more embodiments will achieve power conversion efficiencies exceeding 30%.

DRAWINGS

[0010] The above-mentioned features and objects of the present disclosure will become more apparent with reference to the following description taken in conjunction with the accompanying drawings wherein like reference numerals denote like elements and in which:

[0011] FIG. **1** is a block diagram representation of a single P-N junction tandem solar cell in accordance with one or more embodiments of the present disclosure.

[0012] FIG. **2** is a more detailed perspective view of FIG. **1** showing the various regions in a single P-N junction tandem solar cell in accordance with one or more embodiments of the present disclosure.

[0013] FIG. **3** is a graphical illustration of a band diagram for the heterojunction of a single P-N junction tandem solar cell in accordance with one or more embodiments of the present disclosure.

[0014] FIGS. **4**A and **4**B are graphical illustrations of the calculated (a) band diagram and (b) electron and hole concentrations for the heterojunction of a single P-N junction tandem solar cell in accordance with one or more embodiments of the present disclosure.

[0015] FIGS. **5**A and **5**B are graphical illustrations of the calculated band diagram for the heterojunction of a single P-N junction tandem solar cell with (a) counterdoping and (b) an insulating interlayer at the interface in accordance with one or more embodiments of the present disclosure.

DETAILED DESCRIPTION

[0016] In general, the present disclosure includes a single P-N junction tandem photovoltaic device. Certain embodiments of the present disclosure will now be discussed with reference to the aforementioned figures, wherein like reference numerals refer to like components.

[0017] Referring now to FIG. **1**, a block diagram illustration of a single P-N junction tandem solar cell **100** is shown generally in accordance with one or more embodiments. One of the layers **102** and **104** is formed as a p-type material while the other of the layers **102** and **104** is formed as an n-type material, such that a single P-N junction **105** exists between the layers **102** and **104**. Each of the layers **102** and **104** can also be described and/or formed as its own subcell within the solar cell **100**. In one or more embodiments, the conduction band edge (CBE) of the top layer **102** in the solar cell is formed to line up with the valence band edge (VBE) of the lower layer **104** in the solar cell **100**. In one embodiment, the solar cell **100** includes a layer **102** of a Group III-nitride alloy and a Si layer **104**. Electrical contacts **106** and **108** are formed, respectively, on the top of or otherwise coupled to the Group III-nitride alloy layer **102** and on the bottom of or