SUBSTRATE GEOMETRY FOR THREE DIMENSIONAL PHOTOVOLTAICS FABRICATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit under 35 U.S.C. §119(e) of U.S. Provisional Application No. 61/537,192, entitled 'Substrate Geometry For Three Dimensional Photovoltaics Fabrication', filed Sep. 21, 2011, which is hereby incorporated herein by reference in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

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[0003] Assignee: National Institute of Standards and Technology

FIELD

[0004] Aspects of the present invention generally relate to photovoltaic devices and, more particularly, to photovoltaic devices having back contacts and methods of making same.

BACKGROUND

[0005] Photovoltaic or solar devices may be used to convert light directly into electrical current. This conversion may be accomplished via the conjunction of n-type and p-type semiconducting materials that separate electron-hole pairs that are created when light is absorbed by the photovoltaic device.

[0006] Three generations of photovoltaic devices currently exist. First generation photovoltaic devices may have thicknesses in a range of from about one hundred (100) micrometers to hundreds (100s) of micrometers. First generation devices are generally thicker than subsequent generations because they may be based on silicon, and the indirect bandgap of silicon may require thicknesses within this range for obtaining a higher efficiency. For example, light might simply pass through the thinner silicon device instead of being absorbed by the silicon material.

[0007] Second generation devices may incorporate thin films of direct bandgap semiconducting materials. Such materials may include cadmium telluride or copper indium gallium diselenide for the p-type material. This p-type material may be classified as an absorber and may constitute the majority of the photovoltaic device. Lower costs may be possible using thin films, as compared to first generation devices, since thin film materials may be deposited using a variety of techniques and less material may be required to obtain a desired efficiency. However, decreased efficiency in light conversion may result when thin film devices are compared to crystalline silicon devices.

[0008] Third generation devices may include three-dimensional (3D) micro- or nano-scale structures (e.g., nano-wires and nano-rods in polymers) to improve their efficiency. Use of such third-generation devices is predicated on their having an even lower cost for conversion of solar energy than second generation devices and/or higher efficiency.

[0009] In connection with the development of second and third generation photovoltaic devices, various geometries are either being used or considered. Such geometries may include a geometry pursuant to which electrical contacts for extracting charge carriers (holes and electrons) are located on opposing surfaces of the thin film.

[0010] In some cases, third generation devices may contain nanoparticles that are dispersed during fabrication, as opposed to being grown on the substrate of the device itself. A drawback to this dispersed configuration may exist in that it may be a challenge to ensure uninterrupted connectivity of all constituent regions to an electrode. It may also be a challenge to connect the nanoparticles to the correct electrode.

[0011] Second and third generation geometries may have drawbacks in that the electrode on the side of the photovoltaic device that faces the sun may absorb or otherwise block some of the incoming light, thus adversely affecting the photovoltaic device's performance while also increasing its cost and processing complexity.

[0012] Advances have been made to address shortcomings associated with the blockage of incoming light caused by the front contacts (on the surface that faces the sun) in first generation devices. Devices that use interdigitated contacts on the back surface (surface not facing the sun) may eliminate light blockage caused by the front contacts. Silicon-based devices have been explored for more than thirty years. Such devices may use line or point contacts created through multiple lithographic patterning (masking) and deposition steps to create localized doping on the back surface of silicon wafers. The doped regions may connect to metal busbars and may also be located on the back surface for extraction of electrical current.

[0013] Sequential masking steps may also be used to create two interleaved arrays of n-type and p-type doped spots (point contacts) on the back surface of a silicon wafer, which may minimize recombination on the area that interfaces between metal and semiconductor. Such back surface interdigitated contacts on silicon wafers may be optimized by spacing the lines on which the doped regions fall. However, this process may be more difficult to implement on a large scale with thin film devices. For example, patterning the electrodes in a single lithographic pattern or layer may result in shorting of the electrodes.

[0014] There is a need for thin film photovoltaic devices that incorporate back contacts thereby reducing blockage of incoming light caused by front contacts.

SUMMARY

[0015] According to one aspect of the present invention, a thin film photovoltaic device with back contacts is disclosed. The thin film photovoltaic device comprises; a first contact disposed in a first layer and having an upper surface and a lower surface; a first semiconductor disposed in a second layer and having a lower surface disposed on the upper surface of the first contact; a patterned insulator or a second semiconductor disposed in a third layer and on an upper surface of the first semiconductor; a second patterned contact disposed in a fourth layer and on the insulator or the second semiconductor; an absorber completely filling a fifth layer and disposed about the second contact; and the second layer being adjacent to the first layer, the third layer being adjacent the second layer, the fourth layer being adjacent the third layer, and the fifth layer being adjacent the fourth layer.