SELF-ALIGNED SELECTIVE EMITTER FORMED BY COUNTERDOPING

[0001] This application claims priority of U.S. Provisional Patent Application Ser. No. 61/146,542, filed Jan. 22, 2009, the disclosure of which is incorporated herein by reference in its entirety.

FIELD

[0002] This invention relates to doping solar cells, and, more particularly, to counterdoping a solar cell.

BACKGROUND

[0003] Ion implantation is a standard technique for introducing conductivity-altering impurities into substrates. A desired impurity material is ionized in an ion source, the ions are accelerated to form an ion beam of prescribed energy, and the ion beam is directed at the surface of the substrate. The energetic ions in the beam penetrate into the bulk of the substrate material and are embedded into the crystalline lattice of the substrate material to form a region of desired conductivity.

[0004] Solar cells are only one example of a device that uses silicon substrates, and these solar cells are becoming more important globally. Any reduced cost to the manufacture or production of high-performance solar cells or any efficiency improvement to high-performance solar cells would have a positive impact on the implementation of solar cells worldwide. This will enable the wider availability of this clean energy technology.

[0005] In fabricating a solar cell, two factors must be considered. The first factor is series resistance (R_s), or the total resistance of the solar cell material. Series resistance limits the fill factor, or the ratio of the maximum power point divided by the product of the open circuit voltage (V_{oc}) and the short circuit current (I_{sc}). As series resistance increases, the voltage drop between the junction voltage and the terminal voltage becomes greater for the same flow of current. This results in a significant decrease in the terminal voltage V and a slight reduction in I_{sc}. Very high values of R_s also produce a significant reduction in I_{sc}. In such regimes, the series resistance dominates and the behavior of the solar cell resembles that of a resistor. Thus, if V_{oc} and/or I_{sc} decrease, then the cell efficiency decreases as well. This decrease may be a linear function in one instance.

[0006] The second factor is photon conversion efficiency, which limits short circuit current. If the front surface of a solar cell is doped at a high level, series resistance will be reduced but recombination loss of the charge carriers increases. This recombination occurs due to interstitial dopants that are not incorporated into the crystal lattice. These dopant sites become recombination centers. This phenomenon is called Shockley-Read-Hall Recombination. A solution that reduces recombination loss is to elevate doping levels only under the front surface contacts of the solar cell. This technique is known as a selective emitter.

[0007] One method in forming a selective emitter in a solar cell is to perform a high-dose implant selectively in a region where the metal contacts will eventually be formed. This requires either an expensive photolithography step or the use of a shadow or stencil mask to perform a selective or patterned implant. If a mask is used, it must be carefully aligned to the eventual contact areas. This requires an accuracy of approximately 10-20 μm for current solar cell designs. Accordingly, there is a need in the art for an improved method of doping solar cells using counterdoping.

SUMMARY

[0008] An improved method of doping substrates, and particularly solar cells, is disclosed. Conductors, such as metal lines, are often deposited on the surface of a substrate. In some embodiments, it is desirable that the conductivity of the substrate beneath the conductors is different than the conductivity of other regions of the substrate. Therefore, the conductors can serve as the mask for a subsequent blanket doping, which changes the conductivity of the surface of the substrate, except beneath the conductors. In some embodiments, an initial blanket doping is performed prior to the deposition of the conductors to create an initial uniformly doped region.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] For a better understanding of the present disclosure, reference is made to the accompanying drawings, which are incorporated herein by reference and in which:

[0010] FIG. **1** is cross-sectional view of an embodiment of an exemplary front surface solar cell;

[0011] FIG. **2** is a perspective view of an embodiment of counterdoping in a solar cell;

[0012] FIG. **3** is a first embodiment of a solar cell fabrication process flow;

[0013] FIG. **4** is a second embodiment of a solar cell fabrication process flow;

[0014] FIG. **5** is a third embodiment of a solar cell fabrication process flow;

[0015] FIG. **6** is a fourth embodiment of a solar cell fabrication process flow;

[0016] FIG. **7** is a fifth embodiment of a solar cell fabrication process flow;

[0017] FIG. **8** is a sixth embodiment of a solar cell fabrication process flow;

[0018] FIGS. **9**A-D show the substrate as it undergoes the solar cell fabrication process flow of FIG. **7**; and

[0019] FIGS. **10**A-C show a substrate as it undergoes another solar cell fabrication process flow.

DETAILED DESCRIPTION

[0020] The embodiments of the process described herein may be performed by, for example, a beam-line ion implanter or a plasma doping ion implanter. Such a plasma doping ion implanter may use RF or other plasma generation sources. Other plasma processing equipment or equipment that generates ions also may be used. Thermal or furnace diffusion, pastes on the surface of the solar cell substrate that are heated, epitaxial growth, or laser doping also may be used to perform certain embodiments of the process described herein. Furthermore, while a silicon solar cell is specifically disclosed, other solar cell substrate materials also may benefit from embodiments of the process described herein.

[0021] FIG. **1** is cross-sectional view of an embodiment of an exemplary front surface solar cell. Other embodiments or designs are possible and the embodiments of the process described herein are not solely limited to the solar cell **100** illustrated in FIG. **1**. The solar cell **100** includes a base region **101** and an emitter **102**. The base **101** and emitter **102** are oppositely doped such that one is n-type and the other is