microns. Such miniaturization is difficult or even impossible for the present methodology of diffusion and screen printing in forming solar cells. Selectively altering the resistivity of regions underneath the metal grid lines with respect to the regions in between the grid lines provides charge collection and generation advantages and thus lead to gain in efficiencies.

Diffusion processes typically use a dopant material that is applied as a paste or sprayed onto the surface of the semiconductor substrate. The semiconductor substrate is then heated to drive the dopant to a particular depth to form a junction. The semiconductor substrate is typically heated in a diffusion furnace or a similar heating means. An n-type or p-type of a dopant can be used to form the junction depending upon the background doping type. A subsequent screen printing step is used to form contact lines onto the surface of the wafer in completing the solar cell.

The interface of the metal contact with the semiconductor affects the performance of the solar cell. Conventionally, the junction between the metal contact and the silicon is heated to form a silicide. This heating process improves the interface, but also includes drawbacks.

Accordingly, it is desirable to provide an improved more economical method of forming a solar cell to overcome the drawbacks of conventional solar cell manufacturing methods, allow production of solar cells with smaller dimensions and having tighter control of the dose and dopant position.

SUMMARY OF THE INVENTION

In accordance with ~~a first aspect~~an embodiment of the present invention, a solar cell device is provided. The device includes a silicon substrate including a preexisting dopant. A homogeneous lightly doped region is formed on a surface of the silicon substrate over the preexisting dopant. A junction is formed between the preexisting dopant and the lightly doped region. The junction is formed a predetermined distance from the surface of the silicon substrate. A heavily doped region is selectively implanted on the surface of the silicon substrate within the lightly doped region. A seed layer is formed over the heavily doped region. A metal contact is formed over the seed layer. The device can include an anti-reflective coating.

In an ~~exemplary~~ embodiment, the device includes the homogeneous lightly doped region having a resistivity in a range of 80 to 160 Ohms/square and the heavily doped region having a resistivity in a range of 10 to 40 Ohms/square. In one embodiment, the homogeneous lightly doped region includes a resistivity of approximately 100 Ohms/square and the heavily doped region includes a resistivity of approximately 25 Ohms/square. The

heavily doped regions can each be a width on the silicon substrate a distance in the range 50 to 200 microns. Also, the heavily doped regions can be laterally spaced on the silicon substrate a distance in the range 1 to 3 mm from each other.

The seed layer can be a silicide. The seed layer can also be a layer of a material including any of the materials Ni, Ta, Ti, W or Cu. The silicon substrate can include fiducial markers configured for aligning the placement of the heavily doped regions during an ion implantation process.

In accordance with ~~a second aspect~~an aspect of the present invention, a method of forming a solar cell device is provided. The method includes providing a silicon substrate including a preexisting dopant. An ion implantation process is used to form a homogeneous lightly doped region on a surface of the silicon substrate over the preexisting dopant. A junction is formed between the preexisting dopant and the lightly doped region. The junction is formed a predetermined distance from the surface of the silicon substrate. A first selective ion implantation process is used to form a heavily doped region implanted on the surface of the silicon substrate within the lightly doped region. The heavily doped region is implanted at predetermined locations on the silicon substrate surface. ~~The~~A second selective ion implantation process is used to form a seed layer over the heavily doped region. A metal contact is formed over the seed layer using the second selective ion implantation process. The method can include forming an anti-reflective coating.

The heavily doped region is implanted at predetermined locations on the silicon substrate surface using a physical mask. The physical mask includes openings aligned with the predetermined locations. The physical mask is formed on the surface of the silicon substrate. The physical mask is positioned at a predetermined distance above the surface of the silicon substrate during the selective ion implantation process to form the heavily doped region. In an alternative embodiment, the selective ion implantation process uses a shaped ion beam that is aligned with the predetermined locations to form the heavily doped region. In a further embodiment, such selective implantation can be done through a mask on the surface of the substrate. A combination of all the above embodiments of forming the heavily doped regions can be used.

In an exemplary embodiment, the homogeneous lightly doped region includes a resistivity in a range of 80 to 160 Ohms/square and the homogeneous lightly doped region includes a resistivity of approximately 100 Ohms/square. The heavily doped region can include a resistivity in a range of 10 to 40 Ohms/square. In one embodiment, the heavily