HIGH VOLTAGE SOLAR MODULES

BACKGROUND

[0001] Photovoltaic (PV) cells, commonly known as solar cells, are well known devices for conversion of solar radiation into electrical energy. Generally, solar radiation impinging on the surface of, and entering into, the substrate of a solar cell 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 creating a voltage differential between the doped regions. The doped regions are connected to the conductive regions on the solar cell to direct an electrical current from the cell to an external circuit. When PV cells are combined in an array such as a PV module, the electrical energy collected from all of the PV cells can provide power with a certain voltage and current.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Figure 1 illustrates a cross-sectional view of a solar cell prior to singulation to form physically separated sub-cells, in accordance with some embodiments.

[0003] Figure 2 illustrates a cross-sectional view of a solar cell subsequent to singulation to form physically separated sub-cells, in accordance with some embodiments.

[0004] Figure 3 illustrates a cross-sections view of a portion of a pair of singulated sub-cells using metal as a back-stop for cell singulation, in accordance with some embodiments.

[0005] Figure 4 illustrates a cross-sections view of a portion of a pair of singulated sub-cells using a buffer material as a back-stop for cell singulation, in accordance with some embodiments.

[0006] Figures 5-9 illustrate plan views of various example solar cells, from the metallization side of the respective solar cell, which have been diced into sub-cells, in accordance with some embodiments.

[0007] Figure 10 illustrates an example high voltage PV module, according to some embodiments.

[0008] Figure 11 illustrates a block diagram of a system that includes a high voltage module and boost-less voltage conversion device, according to some embodiments.

[0009] Figures 12a-12c illustrate example performance for example 96-cell high voltage modules, according to some embodiments.

[0010] Figures 13a-13d illustrate example shading scenarios for example 96-cell high voltage modules.

[0011] Figures 14a-14c illustrate example performance for example 60-cell high voltage modules, according to some embodiments

SUMMARY

[0011a] According to an aspect, a photovoltaic module is provided, comprising a high voltage photovoltaic laminate that includes a plurality of high voltage photovoltaic cells, wherein each of the

plurality of high voltage photovoltaic cells includes a plurality of sub-cells; and a boost-less voltage conversion device configured to convert a first voltage from the high voltage photovoltaic laminate to a second voltage, wherein the boost-less voltage conversion device includes a high frequency isolation transformer with a switching frequency greater than 100 KHz.

[0011b] According to an aspect, a photovoltaic system is provided, comprising a first high voltage photovoltaic module; and a first boost-less microinverter coupled to the first high voltage photovoltaic module, wherein the first boost-less microinverter is configured to convert a direct current (DC) voltage to an alternating current (AC) voltage, wherein the first boost-less microinverter is coupled to a second boost-less microinverter that is coupled to a second high voltage photovoltaic module ,wherein the first boost-less microinverter includes a high frequency isolation transformer with a switching frequency greater than 100 KHz.

[0011c] According to an aspect, a junction box is provided, comprising a housing coupled to a photovoltaic laminate; and a boost-less microinverter within the housing, wherein the microinverter is configured to convert a direct current (DC) voltage to an alternating current (AC) voltage. , wherein the microinverter includes an isolation transformer with a switching frequency greater than 100 KHz

DETAILED DESCRIPTION

[0012] The following detailed description is merely illustrative in nature and is not intended

CLAIMS

What is claimed is:

1. A photovoltaic module, comprising:

a high voltage photovoltaic laminate that includes a plurality of high voltage photovoltaic cells, wherein each of the plurality of high voltage photovoltaic cells includes a plurality of sub-cells; and

a boost-less voltage conversion device configured to convert a first voltage from the high voltage photovoltaic laminate to a second voltage, wherein the boost-less voltage conversion device includes a high frequency isolation transformer with a switching frequency greater than 100 KHz.

2. The photovoltaic module of claim 1, wherein the boost-less voltage conversion device is a boost-less microinverter, wherein the first voltage is a direct current (DC) voltage and the second voltage is an alternating current (AC) voltage.

3. The photovoltaic module of claim 1, further comprising a junction box, wherein the boost-less voltage conversion device is located inside a housing of the junction box.

4. The photovoltaic module of claim 1, wherein the plurality of sub-cells for a particular one of the photovoltaic cells are connected in series, and wherein the plurality of photovoltaic cells are also connected in series.

5. The photovoltaic module of claim 1, wherein the boost-less voltage conversion device is further configured to convert the second voltage to a third voltage.

6. The photovoltaic module of claim 1, wherein the boost-less voltage conversion device has $V_{mp} > 1.43\ V_{grid}$.

7. The photovoltaic module of claim 1, wherein the boost-less voltage conversion device is a boost-less direct current (DC) power optimizer with isolation, wherein both the first and second voltages are DC voltages.

8. The photovoltaic module of claim 1, wherein the boost-less voltage conversion device is configured to provide the second voltage to a power grid.

9. The photovoltaic module of claim 1, wherein the boost-less voltage conversion device is further configured to operate in a bypass mode dependent on a Vmp of the high voltage photovoltaic module falling below a threshold value.

10. A photovoltaic system, comprising:

a first high voltage photovoltaic module; and

a first boost-less microinverter coupled to the first high voltage photovoltaic module, wherein the first boost-less microinverter is configured to convert a direct current (DC) voltage to an alternating current (AC) voltage, wherein the first boost-less microinverter is coupled to a second boost-less microinverter that is coupled to a second high voltage photovoltaic module, wherein the first boost-less microinverter includes a high frequency isolation transformer with a switching frequency greater than 100 KHz.

11. The photovoltaic system of claim 10, further comprising:

a junction box coupled to the first high voltage photovoltaic module, wherein the first boost-less microinverter is located within the junction box.

12. The photovoltaic system of claim 10, wherein the first high voltage photovoltaic module includes a plurality of photovoltaic cells, wherein each of the plurality of photovoltaic cells includes a plurality of sub cells.

13. The photovoltaic system of claim 10, further comprising:

the second high voltage photovoltaic module; and

the second boost-less microinverter coupled to the second high voltage photovoltaic module, wherein the second boost-less microinverter is coupled to a third boost-less

microinverter that is coupled to a third high voltage photovoltaic module, wherein the first, second, and third high voltage photovoltaic modules are connected in series.

14. The photovoltaic system of claim 10, wherein the first boost-less microinverter has Vmp > 1.43 Vgrid.

15. The photovoltaic system of claim 10, wherein the first boost-less microinverter is further configured to switch into a different mode based, at least in part, on a Vmp of the first high voltage photovoltaic module falling below a threshold value

16. A junction box, comprising:

a housing coupled to a photovoltaic laminate; and

a boost-less microinverter within the housing, wherein the microinverter is configured to convert a direct current (DC) voltage to an alternating current (AC) voltage, wherein the microinverter includes an isolation transformer with a switching frequency greater than 100 KHz.

17. The junction box of claim 16, wherein the photovoltaic laminate is a high voltage photovoltaic laminate.