embodiment of the present disclosure.

[0008] Figure 4A illustrates a plan view from the metallization side of a solar cell that has been diced into four parallel connected sub-cells, in accordance with an embodiment of the present disclosure.

[0009] Figure 4B illustrates a plan view from the metallization side of another solar cell that has been diced into four parallel sub-cells, in accordance with another embodiment of the present disclosure.

[0010] Figure 5A illustrates a plan view from the metallization side of a solar cell that has been diced into two sub-cells in a parallel arrangement, in accordance with an embodiment of the present disclosure.

[0011] Figure 5B illustrates a plan view from the metallization side of a solar cell that has been diced into two sub-cells in an in series arrangement, in accordance with an embodiment of the present disclosure.

[0012] Figure 5C illustrates a plan view from the metallization side of a solar cell that has been diced into six sub-cells in a series arrangement, in accordance with an embodiment of the present disclosure.

[0013] Figure 5D illustrates a plan view from the metallization side of a solar cell that has been diced into ten sub-cells in a series arrangement, in accordance with an embodiment of the present disclosure.

[0014] Figure 6 illustrates a representative example of cell singulation considerations and approaches, in accordance with one or more embodiments of the present disclosure.

[0015] Figure 7 illustrates three possible pathways for laser scribing for singulation of a solar cell to form sub-cells, in accordance with an embodiment of the present disclosure.

[0016] Figure 8 is a flowchart representing operations in a method of fabricating a solar cell using singulation to form sub-cells, in accordance with an embodiment of the present disclosure.

[0017] Figure 9 is a flowchart representing operations in another method of fabricating a solar cell using singulation to form sub-cells, in accordance with another embodiment of the present disclosure.

SUMMARY

[0017a] According to an aspect, a solar cell is provided comprising a plurality of sub-cells, each of the sub-cells comprising a singulated and physically separated semiconductor substrate portion, wherein adjacent ones of the singulated and physically separated semiconductor substrate portions have a groove there between; and

a monolithic metallization structure, wherein a portion of the monolithic metallization structure couples ones of the plurality of sub-cells, wherein the groove between adjacent ones of the singulated and physically separated semiconductor substrate portions exposes a portion of the monolithic metallization structure. The monolithic metallization structure ties the plurality of sub-cells together as a backplane.

[0017b] According to another aspect, a method of fabricating a solar cell is provided, comprising:

forming a monolithic metallization structure on a first surface of a semiconductor substrate; and

scribing the semiconductor substrate from a second, opposite, surface of the semiconductor substrate, the scribing stopped by and exposing portions of the monolithic metallization structure from the second surface. The scribing comprises forming a plurality of sub-cells, each of the sub-cells being tied by the monolithic metallization structure as a backplane.

[0017c] According to an aspect, a method of fabricating a solar cell including a semiconductor substrate having a first surface, the method comprising:

forming an interconnect between at least two sub-solar cells of the solar cell directly on the first surface of the semiconductor substrate to provide an electrical inter-cell connection there between before dicing the semiconductor substrate up to the first surface to physically isolate the at least two sub-solar cells. Forming the interconnect between at least two sub-solar cells of the solar cell further comprises forming a monolithic metallization structure on the first surface of the semiconductor substrate of the solar cell. Each of the at least two sub-solar cells is tied by the monolithic metallization structure as a backplane.

DETAILED DESCRIPTION

[0018] The following detailed description is merely illustrative in nature and is not intended to limit the embodiments of the subject matter or the application and uses of such embodiments. As used herein, the word "exemplary" means "serving as an example, instance, or illustration." Any implementation described herein as exemplary is not necessarily to be construed as preferred or advantageous over other implementations. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field, background, brief summary or the following detailed description.

CLAIMS

What is claimed is:

1. A solar cell, comprising:

a plurality of sub-cells, each of the sub-cells comprising a singulated and physically separated semiconductor substrate portion, wherein adjacent ones of the singulated and physically separated semiconductor substrate portions have a groove there between; and

a monolithic metallization structure, wherein a portion of the monolithic metallization structure couples ones of the plurality of sub-cells, wherein the groove between adjacent ones of the singulated and physically separated semiconductor substrate portions exposes a portion of the monolithic metallization structure, wherein the monolithic metallization structure ties the plurality of sub-cells together as a backplane.

2. The solar cell of claim 1, wherein the solar cell further comprises:

an encapsulating material disposed in the groove between adjacent ones of the singulated and physically separated semiconductor substrate portions.

3. The solar cell of claim 1, wherein each of the sub-cells has a same voltage characteristic and a same current characteristic.

4. The solar cell of claim 1, wherein the plurality of sub-cells is a plurality of in-parallel diodes, in-series diodes, or a combination thereof.

5. The solar cell of claim 1, wherein the solar cell is a back contact solar cell, and wherein the monolithic metallization structure is disposed on a back surface, opposite a light-receiving surface, of each of the singulated and physically separated semiconductor substrate portions.

6. The solar cell of claim 5, wherein the current generated by each of the sub-cells is the same.

7. The solar cell of claim 5, wherein the light-receiving surface of each of the sub-cells is a texturized surface.

8. The solar cell of claim 1, wherein each of the singulated and physically separated semiconductor substrate portions is a bulk monocrystalline silicon substrate portion.

9. A photovoltaic module comprising a plurality of the solar cells of claim 1.

10. The photovoltaic (PV) module of claim 9, wherein, for each solar cell, an encapsulating material of a laminate of the PV module is disposed in the groove between adjacent ones of the singulated and physically separated semiconductor substrate portions.

11. A method of fabricating a solar cell, the method comprising:

forming a monolithic metallization structure on a first surface of a semiconductor substrate; and

scribing the semiconductor substrate from a second, opposite, surface of the semiconductor substrate, the scribing stopped by and exposing portions of the monolithic metallization structure from the second surface, wherein the scribing comprises forming a plurality of sub-cells, each of the sub-cells being tied by the monolithic metallization structure as a backplane.

12. The method of claim 11, wherein forming the monolithic metallization structure on the first surface of the semiconductor substrate comprises patterning a metal foil formed on the first surface of the semiconductor substrate.

13. The method of claim 11, wherein forming the monolithic metallization structure on the first surface of the semiconductor substrate comprises plating one or more metal films on portions of the first surface of the semiconductor substrate.

14. The method of claim 11, wherein the scribing comprising scribing with a laser.

15. The method of claim 11, further comprising:

prior to scribing the semiconductor substrate, texturizing the second surface of the semiconductor substrate.

16. The method of claim 11, wherein each of the sub-cells comprising a singulated and physically separated portion of the semiconductor substrate having a groove between

adjacent ones of the singulated and physically separated semiconductor substrate portions, wherein the monolithic metallization structure couples ones of the plurality of sub-cells.

17. The method of claim 16, further comprising:

forming an encapsulating material in the groove between adjacent ones of the singulated and physically separated semiconductor substrate portions.

18. The method of claim 16, wherein forming the plurality of sub-cells comprises forming each of the sub-cells to have a same voltage characteristic and a same current characteristic.

19. The method of claim 16, wherein forming the plurality of sub-cells comprises forming a plurality of in-parallel diodes, in-series diodes, or a combination thereof.

20. The method of claim 16, further comprising:

subsequent to scribing the semiconductor substrate, embedding the solar cell in a photovoltaic (PV) module laminate, wherein an encapsulating material of the PV module laminate fills the groove between adjacent ones of the singulated and physically separated semiconductor substrate portions.

21. A solar cell fabricated according to the method of claim 11.

22. A method of fabricating a solar cell including a semiconductor substrate having a first surface, the method comprising:

forming an interconnect between at least two sub-solar cells of the solar cell directly on the first surface of the semiconductor substrate to provide an electrical inter-cell connection there between before dicing the semiconductor substrate up to the first surface to physically isolate the at least two sub-solar cells, wherein forming the interconnect between at least two sub-solar cells of the solar cell further comprises forming a monolithic metallization structure on the first surface of the semiconductor substrate of the solar cell, wherein each of the at least two sub-solar cells being tied by the monolithic metallization structure as a backplane.

23. The method of claim 22, wherein dicing the semiconductor substrate further comprises:

scribing the semiconductor substrate from a second, opposite, surface of the semiconductor substrate

24. The method of claim 23, wherein scribing the semiconductor substrate further comprises:

stopping the scribing upon exposing portions of the monolithic metallization structure from the second surface.

25. The method of claim 23, wherein the stopping the scribing upon exposing portions of the monolithic metallization structure from the second surface comprises stopping on a buffer damage layer selected from the group consisting of a polymer layer, a metal layer, and a metal mesh.

26. The method of claim 23, wherein scribing the semiconductor substrate further comprises:

forming a groove between the at least two sub-solar cells such that the monolithic metallization structure electrically couples portions of the at least two sub-solar cells; and

forming an encapsulating material in the groove.

27. The method of claim 22, wherein dicing the semiconductor substrate further comprises:

forming at least one diode in each of the at least two sub-solar cells; and

forming each of the at least two sub-solar cells to have a same voltage characteristic and a same current characteristic.

28. The method of claim 27, wherein forming at least one diode in each of the at least two sub-solar cells further comprises:

forming a P-type dopant region and a N-type dopant region in the at least one diode of each of the at least two sub-solar cells;

forming a first metal contact to the P-type dopant region; and

forming a second metal contact to the N-type dopant region.

29. The method of claim 22, wherein forming the monolithic metallization structure further comprises:

substantially simultaneously to forming of the monolithic metallization structure plating one or more metal films on portions of the first surface of the semiconductor substrate.

30. The method of claim 22, wherein forming the monolithic metallization structure further comprises:

patterning a metal foil formed on the first surface of the semiconductor substrate.

31. The method of claim 23, further comprising:

prior to scribing the semiconductor substrate, texturizing the second surface of the semiconductor substrate.