Method of Cutting an Ingot for Solar Cell Fabrication

TECHNICAL FIELD

[0001] Embodiments of the present invention are in the field of renewable energy and, in particular, methods of cutting ingots for solar cell fabrication.

BACKGROUND

[0002] Ingot slicing, such as silicon ingot slicing, into wafers typically involves using a rectangular beam piece epoxy glued to the ingot. A wire saw work piece is used to hold the beam during the slicing process. Upon completion of slicing, e.g., with a multi-wire web having completely sliced through the ingot and into the beam, a clean separation of the formed wafers must be performed. The separation from the beam must be made with care in order to preserve the final edge of the formed wafers. Following wireweb slicing, the sliced ingot is often loaded into a debond and precleaner tool and undergoes pre-cleaning followed by the epoxy degluing process. Beams used are typically composed of glass for the slurry slicing, or graphite or resin materials for diamond-wire slicing.

SUMMARY

[0002a] According to a first aspect of the invention, there is provided a method of cutting a semiconductor~~an~~ ingot for fabricating a plurality of solar cells, the method comprising: gripping a portion of the semiconductor ingot directly with a gripper of a cutting apparatus; partially cutting the semiconductor ingot to form a plurality of wafer portions projecting from an uncut portion of the semiconductor ingot; and further cutting the semiconductor ingot to separate the plurality of wafer portions from the uncut portion, providing a plurality of discrete wafers.

[0002b] According to a second aspect of the invention, there is provided a semiconductor~~an~~ ingot for fabricating a plurality of solar cells, the semiconductor ingot comprising: four major surfaces oriented along a central axis of the semiconductor ingot, the first major surface different structurally from two or more of the remaining three major surfaces; and a pair of ends approximately orthogonal to the four major surfaces, wherein the pair of ends can be gripped directly with a gripper of a cutting apparatus.

CLAIMS

What is claimed is:

1. A method of cutting ~~a~~an semiconductor ingot for fabricating a plurality of solar cells, the method comprising:

gripping a portion of the semiconductor ingot directly with a gripper of a cutting apparatus;

partially cutting the semiconductor ingot to form a plurality of wafer portions projecting from an uncut portion of the semiconductor ingot;

further cutting the semiconductor ingot to separate the plurality of wafer portions from the uncut portion, providing a plurality of discrete wafers.

2. The method of claim 1, wherein gripping the portion of the semiconductor ingot comprises gripping at both ends of the semiconductor ingot along a first of four major surfaces oriented along a central axis of the semiconductor ingot, the first major surface different structurally from two or more of the remaining three major surfaces.

3. The method of claim 2, wherein the semiconductor ingot comprises mono-crystalline silicon, the remaining three major surfaces each comprise a substantially flat portion having a surface area, and the first major surface comprises a substantially flat portion having a surface area less than each of the surfaces areas of the substantially flat portions of the remaining three major surfaces.

4. The method of claim 3, wherein further cutting the semiconductor ingot comprises forming the plurality of discrete wafers to each comprise four major edges of approximately the same length.

5. The method of claim 2, wherein the semiconductor ingot comprises multi-crystalline silicon, the four major surfaces forming a rectangular cross-section, and wherein the first major surface is a short side of the rectangular cross-section.

6. The method of claim 5, wherein further cutting the semiconductor ingot comprises forming the plurality of discrete wafers to each comprise four major edges that approximately form a square.

7. The method of claim 1, wherein gripping the portion of the semiconductor ingot comprises gripping at both ends of the semiconductor ingot, into keyholes formed at each of the both ends of the semiconductor ingot.

8. The method of claim 7, wherein further cutting the semiconductor ingot to separate the plurality of wafer portions from the uncut portion comprises separating the plurality of discrete wafers from a portion of the semiconductor ingot comprising the keyholes.

9. The method of claim 8, wherein the portion of the semiconductor ingot comprising the keyholes has a thickness of approximately, or greater than 10 mm parallel ~~with the direction of the plurality of wafer portions~~to the central axis of the semiconductor ingot.

10. The method of claim 1, wherein both partially cutting and further cutting the semiconductor ingot comprises using a same wire cutting technique selected from the group consisting of diamond wire cutting and slurry slicing.

11. The method of claim 10, wherein the partially cutting the semiconductor ingot and the further cutting the semiconductor ingot are performed approximately orthogonal to one another, based on movement of the gripper relative to the wire cutting technique.

12. The method of claim 11, wherein the further cutting is performed based on an approximately 1 pitch movement of the gripper relative to the wire cutting technique along a long axis of the semiconductor ingot.

13. The method of claim 1, wherein further cutting the semiconductor ingot comprises supporting the plurality of wafer portions with a wafer-receiving catcher to provide the plurality of discrete wafers directly into the wafer catcher.

14. The method of claim 1, further comprising:

reusing the uncut portion of the semiconductor ingot to form a second semiconductor ingot.

~~15. A solar cell fabricated according to the method of claim 1.~~

1516. A~~An~~ semiconductor ingot for fabricating a plurality of solar cells, the semiconductor ingot comprising:

four major surfaces oriented along a central axis of the semiconductor ingot, the first major surface different structurally from two or more of the remaining three major surfaces; and

a pair of ends approximately orthogonal to the four major surfaces, wherein the pair of ends can be gripped directly with a gripper of a cutting apparatus.

1617. The semiconductor ingot of claim ~~16~~15, wherein the semiconductor ingot comprises mono-crystalline silicon, the remaining three major surfaces each comprise a substantially flat portion having a surface area, and the first major surface comprises a substantially flat portion having a surface area less than each of the surfaces areas of the substantially flat portions of the remaining three major surfaces.

~~18~~17. The semiconductor ingot of claim ~~16~~15, wherein the semiconductor ingot comprises multi-crystalline silicon, the four major surfaces forming a rectangular cross-section, and wherein the first major surface is a short side of the rectangular cross-section.

~~19~~18. The semiconductor ingot of claim ~~16~~15, further comprising:

keyholes formed at each of the both ends of the semiconductor ingot.

~~20~~19. The semiconductor ingot of claim ~~19~~18, wherein the keyholes are formed proximate to the first major surface.