with the surface 111 of the melt 104. The pulling mechanism 114 is operated to pull the seed crystal 122 from the melt 104. Referring now to FIG. 6, the ingot 113 includes a crown portion 142 in which the ingot transitions and tapers outward from the seed crystal 122 to reach a target diameter. The ingot 113 includes a constant diameter portion 145 or cylindrical "main body" of the crystal which is grown by increasing the pull rate. The main body 145 of the ingot 113 has a relatively constant diameter. The ingot 113 includes a tail or end-cone (not shown) in which the ingot tapers in diameter after the main body 145. When the diameter becomes small enough, the ingot 113 is then separated from the melt 104. Generally, the crystal growth process is a batch process in which solid silicon is initially added to the crucible assembly to form a silicon melt without additional solid-silicon being added to the crucible assembly 102 during crystal growth (as opposed to a continuous Czochralski process in which an amount of silicon is added to the crucible assembly during ingot growth).

[0031] The ingot puller apparatus 100 includes a side heater 135 and a susceptor 106 that encircles the crucible assembly 102 to maintain the temperature of the melt 104 during crystal growth. The side heater 135 is disposed radially outward to the crucible sidewall 131 as the crucible assembly 102 travels up and down the pull axis A. The side heater 135 and bottom heater 126 may be any type of heater that allows the side heater 135 and bottom heater 126 to operate as described herein. In some embodiments, the heaters 135, 126 are resistance heaters. The side heater 135 and bottom heater 126 may be controlled

least 0.6). In other embodiments, the kick plate extends across at least 70% of the inner diameter D_{150} of the conduit portion 150, or extends across at least 75%, at least 80%, from 60% to 100%, from 70% to 100%, from 80% to 100%, from 60% to 90%, or from 70% to about 90% of the inner diameter D150 of the conduit portion 150.

[0039] The kick plate 153 and conduit portion 150 of the silicon feed tube 190 form an inner corner 179 and an outer corner 180. The kick plate 153 has an upper end 185 that is aligned with the inner corner 179 and has a lower end 182. The kick plate 153 has a height H_{153} that extends from its upper end 185 to the lower end 182.

[0040] The conduit portion 150 has a lower end 175. In the illustrated embodiment, the conduit portion 150 (e.g., the portion opposite the kick plate 153 as in the illustrated embodiment) includes a portion that vertically overlaps the kick plate 153. The length of this portion that overlaps the kick plate 153 is indicated by H_{150} in FIG. 9. In some embodiments, the conduit portion 150 overlaps less than 70% of the height H_{153} of the kick plate (i.e., the ratio H_{150}/H_{153} is less than 0.7). In some embodiments, the conduit portion 150 overlaps less than 60% of the height of the kick plate or less than 50%, less than 40%, from 20% to 70%, or from 20% to 60% of the height of the kick plate 153.

[0041] Compared to conventional silicon feed tubes, the silicon feed tubes of the present disclosure have several advantages. By using a kick plate that extends to at least 60% of the inner diameter of the conduit portion, solid silicon exits the silicon feed tube away

CLAIMS:

1. An ingot puller apparatus for manufacturing a single crystal silicon ingot, the ingot puller apparatus comprising:

a crucible assembly for holding a silicon melt;

a crystal puller housing that defines a growth chamber for pulling a silicon ingot from the silicon melt, the crucible assembly being disposed within the growth chamber; and

a silicon feed tube for adding solid silicon to the crucible assembly, the silicon feed tube comprising:

a conduit portion having an inner diameter; and

a kick plate disposed below the conduit portion, the kick plate extending across at least 60% of the inner diameter of the conduit portion.

2. The ingot puller apparatus as set forth in claim 1 wherein the kick plate extends across at least 70% of the inner diameter of the conduit portion, or at least 75%, at least 80%, from 60% to 100%, from 70% to 100%, from 80% to 100%, from 60% to 90%, or from 70% to about 90% of the inner diameter of the conduit portion.

3. The ingot puller apparatus as set forth in claim 1 or claim 2 wherein the conduit portion and the kick plate are made of silicon.

4. The ingot puller apparatus as set forth in any one of claims 1 to 3 wherein the kick plate is part of a guide section of the silicon feed tube, the silicon feed tube further comprising a tube section disposed above the guide section.

5. The ingot puller apparatus as set forth in claim 4 wherein the guide section comprises at least a portion of the conduit portion of the silicon feed tube.

6. The ingot puller apparatus as set forth in claim 4 wherein the tube section comprises the entire conduit portion of the silicon feed tube.

7. The ingot puller apparatus as set forth in any one of claims 4 to 6 wherein the guide section and the tube section are separate components that are interconnected.

8. The ingot puller apparatus as set forth in any one of claims 4 to 6 wherein the guide section and tube section are integrally formed from a single piece of material.

9. The ingot puller apparatus as set forth in any one of claims 4 to 8 wherein the tube section is made of silicon.

10. The ingot puller apparatus as set forth in any one of claims 1 to 9 wherein the silicon feed tube comprises a longitudinal axis, the kick plate and longitudinal axis forming an angle and between 20° and 60°.

11. The ingot puller apparatus as set forth in any one of claims 1 to 10 wherein the kick plate has a height, wherein the conduit portion overlaps less than 70% of the height of the kick plate.

12. An ingot puller apparatus for manufacturing a single crystal silicon ingot, the ingot puller apparatus comprising:

a crucible assembly for holding a silicon melt;

a crystal puller housing that defines a growth chamber for pulling a silicon ingot from the silicon melt, the crucible assembly being disposed within the growth chamber; and

a silicon feed tube for adding solid silicon to the crucible assembly, the silicon feed tube comprising:

a conduit portion; and

a kick plate partially disposed below the conduit portion, the kick plate having a height, wherein the conduit portion overlaps less than 70% of the height of the kick plate.

13. The ingot puller apparatus as set forth in claim 12 wherein the conduit portion overlaps less than 60% of the height of the kick plate or less than 50%, less than 40%, from 0% to 70%, from 0% to 60%, from 20% to about 70%, or from 20% to 60% of the height of the kick plate.

14. The ingot puller apparatus as set forth in claim 12 or claim 13 wherein the conduit portion and the kick plate are made of silicon.

15. The ingot puller apparatus as set forth in any one of claims 12 to 14 wherein the kick plate is part of a guide section of the silicon feed tube, the silicon feed tube further comprising a tube section disposed above the guide section.

16. The ingot puller apparatus as set forth in claim 15 wherein the guide section comprises at least a portion of the conduit portion of the silicon feed tube.

17. The ingot puller apparatus as set forth in claim 15 wherein the tube section comprises the entire conduit portion of the silicon feed tube.

18. The ingot puller apparatus as set forth in any one of claims 15 to 17 wherein the guide section and tube section are separate components that are interconnected.

19. The ingot puller apparatus as set forth in any one of claims 15 to 17 wherein the guide section and tube section are integrally formed from a single piece of material.

20. The ingot puller apparatus as set forth in any one of claims 15 to 19 wherein the tube section is made of silicon.

21. The ingot puller apparatus as set forth in any one of claims 12 to 20 wherein the silicon feed tube comprises a longitudinal axis, the kick plate and longitudinal axis forming an angle between 20° and 60°.