CLAIMS:

1. An ingot puller apparatus for producing a silicon ingot comprising:

a crucible for holding a melt of silicon, the crucible having a floor and a sidewall that extends from the floor;

a growth chamber for pulling a silicon ingot from the melt along a pull axis;

a lift mechanism for raising and lowering the crucible during crystal growth relative to the pull axis, the crucible moving axially between a lowest position in which a charge of silicon is melted to produce the silicon melt, a seed-dip position at which a seed crystal is initially contacted with the melt to pull the silicon ingot from the melt, and a terminal position in which the crucible has been depleted of melt;

a side heater disposed radially outward to the crucible sidewall as the crucible travels from the lowest position to the terminal position;

a bottom heater disposed below the crucible floor; and

a heat shield disposed directly below the side heater, wherein a first portion of the heat shield is radially inward to the side heater and a second portion of the heat shield is radially outward to the side heater.

2. The ingot puller apparatus as set forth in claim 1 wherein the side heater is fully above the floor of the crucible when the crucible is in the lowest position.

3. The ingot puller apparatus as set forth in claim 1 or claim 2 wherein at least a portion of the heat shield is above a bottom of the crucible when the crucible is in the lowest position.

4. The ingot puller apparatus as set forth in any one of claims 1 to 3 wherein at least a portion of the heat shield is below at least a portion of the floor of the crucible when the crucible is in the lowest position.

5. The ingot puller apparatus as set forth in any one of claims 1 to 4 wherein the heat shield is fully below the floor of the crucible when the crucible is in the terminal position.

6. The ingot puller apparatus as set forth in any one of claims 1 to 5 wherein the side heater has a length of 500 mm or less.

7. The ingot puller apparatus as set forth in any one of claims 1 to 6 wherein the heat shield has a length relative to the pull axis that is greater than a thickness of the heat shield.

8. The ingot puller apparatus as set forth in any one of claims 1 to 7 wherein at least a portion of the side heater is laterally aligned with the sidewall of the crucible as the crucible travels between the lowest position and the terminal position.

9. The ingot puller apparatus as set forth in any one of claims 1 to 8 wherein the side heater and the heat shield are separated by a gap.

10. The ingot puller apparatus as set forth in any one of claims 1 to 9 wherein the side heater is not separated from the heat shield by a gap.

11. The ingot puller apparatus as set forth in any one of claims 1 to 10 further comprising a susceptor that supports the crucible, the heat shield being fully below the susceptor when the crucible is in the terminal position.

12. The ingot puller apparatus as set forth in any one of claims 1 to 11 wherein a distance between a bottom of the crucible and a bottom of the side heater is at least 25 mm when the crucible is in the lowest position.

13. The ingot puller apparatus as set forth in any one of claims 1 to 11 wherein the side heater has a thickness and the heat shield has a thickness, the thickness of the heat shield being at least the thickness of the side heater or being at least 1.5 times the thickness of the side heater.

14. The ingot puller apparatus as set forth in any one of claims 1 to 13 comprising bottom insulation, the bottom insulation and heat shield being separated by a gap.

15. A method for preparing an ingot in an ingot puller apparatus comprising a crucible having a floor and sidewall extending from the floor, a side heater disposed radially outward to the crucible sidewall, and a heat shield disposed directly below the side heater, a first portion of the heat shield being radially inward to the side heater and a second portion of the heat shield being radially outward to the side heater, the method comprising:

forming a melt of silicon in the crucible when the crucible is in a lowest position, the side heater being fully above the floor of the crucible when the crucible is in the lowest position;

contacting the melt with a seed crystal;

withdrawing an ingot from the silicon melt; and

raising the crucible as the ingot is withdrawn from the silicon melt, the crucible being in a terminal position when the ingot is separated from the melt.

16. The method as set forth in claim 15wherein at least a portion of the heat shield is above a bottom of the crucible when the crucible is in the lowest position.

17. The method as set forth in claim 15 or claim 16 wherein at least a portion of the heat shield is below at least a portion of the floor of the crucible when the crucible is in the lowest position.

18. The method as set forth in any one of claims 15 to 17 wherein the heat shield is fully below the floor of the crucible when the crucible is raised to the terminal position.

19. The method as set forth in any one of claims 15 to 18 wherein the side heater has a length of 350 mm or less.

20. The method as set forth in any one of claims 15 to 19 wherein the ingot puller apparatus comprises bottom insulation, the bottom insulation and heat shield being separated by a gap.