urges the clamping fingers to pivot into an engaging position adapted for connecting the end of the ingot receiving vessel to the clamp base when the support ring moves from the first position to the second position. The clamp also includes at least one actuator controllable to move the support ring between the first and second positions.

[0010] Various refinements exist of the features noted in relation to the above-mentioned aspects of the present disclosure. Further features may also be incorporated in the above-mentioned aspects of the present disclosure as well. These refinements and additional features may exist individually or in any combination. For instance, various features discussed below in relation to any of the illustrated embodiments of the present disclosure may be incorporated into any of the above-described aspects of the present disclosure, alone or in any combination.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a schematic cross section of an ingot pulling apparatus for forming a single crystal silicon ingot.

[0012] FIG. 2 is a perspective of a portion of the ingot pulling apparatus, depicting an ingot receiving vessel connected to an isolation valve by an example clamp.

[0013] FIG. 3 is a cross section showing the connection between the ingot receiving vessel and the isolation valve facilitated by the example clamp in greater detail.

or eliminates engagement between the support ring 244 and the clamping finger 226 when the support ring 244 is in a first, lowered position adjacent the clamp base 202 (shown in FIG. 4).

[0052] When the support ring 244 is in the first position adjacent the clamp base 202, the clamping fingers 226 are maintained in the idle position by the spring clips 242. As the support ring 244 is moved from the first position towards a second, raised position adjacent the clamp cover 248 (shown in FIG. 3), engagement between the support ring 244 and clamping fingers 226 gradually increases. As the support ring is moved towards the second position, the angled surface 270 engages the flat surface portion of the back surface 266 of a respective clamping finger 226, urging the clamping finger 226 to pivot towards the engaging position. As movement of the support ring 244 towards the second position continues, the engagement transitions to the inner surface 258 engaging the flat surface portion of the back surface 266 of each clamping finger 226. At this stage, each clamping finger 226 is in the engaging position.

[0053] The one or more actuators 224 of the clamp 200 are controllable to cause movement of the support ring 244 between the first and second positions, which respectively translate to the clamping fingers 226 being in the idle and engaging positions, and the clamping mechanism 222 being in the releasing and engaging positions. In the example clamp 200, the one or more actuators 224 are pneumatic cylinders. In other examples, any suitable actuator may be used as the one or more actuators 224 to enable the clamp 200 to function as described.

CLAIMS:

1. An ingot puller apparatus for producing a single crystal semiconductor ingot, the ingot puller apparatus comprising:

a housing defining a growth chamber and a growth chamber outlet;

an isolation valve having a first valve end connected to the growth chamber outlet and an opposite second valve end;

an ingot receiving vessel defining an ingot receiving chamber and a receiving chamber inlet at a receiving vessel end;

a clamp including a clamp base connected to the second valve end, a clamping mechanism to releasably connect the receiving vessel end to the clamp base, and at least one actuator controllable to cause movement of the clamping mechanism between a clamping position in which the clamping mechanism connects the receiving vessel end to the clamp base, and a releasing position in which the receiving vessel end is releasable from the clamp base; and

a controller connected to the at least one actuator to control the at least one actuator to cause movement of the clamping mechanism between the clamping and releasing positions;

wherein the clamping mechanism comprises at least one clamping finger pivotably connected to the clamp base and a support ring moveable relative to the clamp base between a first position in which the clamping mechanism is in the releasing position, and a second position in which the clamping mechanism is in the clamping position, the at least one actuator controllable to cause movement of the

support ring between the first and second positions, wherein the support ring urges the at least one clamping finger to pivot into engagement with the receiving vessel end when the support ring moves from the first position to the second position.

2. The ingot puller apparatus of claim 1, wherein the at least one clamping finger comprises two or more clamping fingers pivotably connected to the clamp base.

3. The ingot puller apparatus of claim 1, wherein the at least one clamping finger comprises six clamping fingers pivotably connected to the clamp base.

4. The ingot puller apparatus of claim 1, wherein the clamp comprises at least one biasing element that urges the at least one clamping finger to pivot out of engagement with the receiving vessel end when the support ring moves from the second position to the first position.

5. The ingot puller apparatus of claim 1, wherein the clamp comprises a retaining pin for selectively maintaining the support ring in the second position.

6. The ingot puller apparatus of claim 5, wherein the retaining pin is operably connected to a motor that causes translational movement of the retaining pin to selectively maintain the support ring in the second position, the motor connected to the controller.

7. The ingot puller apparatus of claim 1, wherein the at least one actuator comprises a pneumatic cylinder.

8. An ingot puller apparatus for producing a single crystal semiconductor ingot, the ingot puller apparatus comprising:

a housing defining a growth chamber and a growth chamber outlet;

an isolation valve having a first valve end connected to the growth chamber outlet and an opposite second valve end;

an ingot receiving vessel defining an ingot receiving chamber and a receiving chamber inlet at a receiving vessel end; and

a clamp including a clamp base connected to the second valve end, at least one clamping finger to releasably connect the receiving vessel end to the clamp base, the at least one clamping finger pivotably connected to the clamp base, and a support ring moveable relative to the clamp base between a first position and a second position, wherein the support ring urges the at least one clamping finger to pivot into engagement with the receiving vessel end when the support ring moves from the first position to the second position to connect the receiving vessel end to the clamp base.

9. The ingot puller apparatus of claim 8, wherein the clamp comprises at least one biasing element that urges the at least one clamping finger to pivot out of engagement with the receiving vessel end when the support ring moves from the second position to the first position.

10. The ingot puller apparatus of claim 8, wherein the clamp comprises at least one actuator controllable to cause movement of the support ring between the first position and the second position.

11. The ingot puller apparatus of claim 10, wherein the at least one actuator comprises a pneumatic cylinder.

12. The ingot puller apparatus of claim 8, wherein the clamp comprises at least one bar extending outward from the support ring to enable an operator to manually move the support ring between the first position and the second position.

13. The ingot puller apparatus of claim 8, wherein the clamp comprises a clamp cover opposite the clamp base, the clamp cover defining an opening sized to receive the receiving vessel end, and guide rails extending between the clamp base and the clamp cover, wherein the support ring is moveable along the guide rails between the first position, in which the support ring is adjacent the clamp base, and the second position, in which the support ring is adjacent the clamp cover.

14. The ingot puller apparatus of claim 8, wherein the clamp base has a surface on which the receiving vessel end is seated when connected to the clamp base and an o-ring that creates a seal between the surface of the clamp base and the receiving vessel end.

15. The ingot puller apparatus of claim 8, wherein the clamp comprises a retaining pin for selectively maintaining the support ring in the second position.

16. The ingot puller apparatus of claim 15, wherein the retaining pin is operably connected to a motor that causes translational movement of the retaining pin to selectively maintain the support ring in the second position.

17. The ingot puller apparatus of claim 15, wherein the retaining pin is operably connected to a manual gear drive to enable an operator to manually cause translational movement of the retaining pin to selectively maintain the support ring in the second position.

18. A releasable clamp for releasably connecting an ingot receiving vessel of an ingot puller apparatus to an isolation valve, the releasable clamp comprising:

a clamp base connectable with an end of the isolation valve;

a clamp cover opposite the clamp base, the clamp cover defining an opening sized for receiving an end of the ingot receiving vessel;

clamping fingers pivotably connected to the clamp base;

a support ring moveable relative to the clamp base between a first position and a second position, wherein the support ring urges the clamping fingers to pivot into an engaging position adapted for connecting the end of the ingot receiving vessel to the clamp base when the support ring moves from the first position to the second position; and

at least one actuator controllable to move the support ring between the first and second positions.

19. The releasable clamp of claim 18, wherein the releasable clamp includes biasing elements for each clamping finger, each biasing element urges the respective clamping finger to pivot out of the engaging position when the support ring moves from the second position to the first position.