Therefore, embodimentsthe object of the present invention seekis to counteract the bending of the crystallization boundary and the loading of the single crystal by thermal stresses in a more advantageous way.

According to an aspect of the present invention, there is providedThe object is achieved by means of a method for producing a single crystal by means of the floating zone method, wherein the single crystal crystallizes with the support of an induction heating coil below a melt zone at a crystallization boundary, and the emission of crystallization heat is impeded by a reflector surrounding the single crystal, characterized in that the single crystal is heated in the region of an outer edge of the crystallization boundary by means of a heating device in a first zone, wherein a distance Δ between an outer triple point T_a at the outer edge of the crystallization boundary and a center Z of the crystallization boundary is influenced such that the region of the single crystal which is heated by means of the heating device has, in the longitudinal direction of the single crystal from the outer triple point T_a, a length L that is not longer than the distance Δ.

According to another aspect of the present invention, there is providedThe object is equally achieved by means of an apparatus for producing a single crystal by means of the floating zone method, comprising a reflector surrounding the single crystal, and a heating device for heating the single crystal in the region of an outer edge of a crystallization boundary of the single crystal, wherein the heating device is dimensioned in such a way that the region of the single crystal which is heated by means of the heating device is, in the longitudinal direction of the single crystal, a first zone, which, from an outer triple point T_a, has a length L that is not longer than a

distance Δ that exists between the outer triple point T_a at the outer edge of the crystallization boundary and a center Z of the crystallization boundary.

The present invention pursues the aim of increasing the temperature in the region of the upper end of the single crystal from the side such that the axial position of the crystallization boundary at the circumference of the single crystal is influenced, to be precise in such a way that the bending of the crystallization boundary, that is to say the vertical distance between the center and the edge of the crystallization boundary, is limited.

The present invention can be applied independently of whether silicon or some other semiconductor material is crystallized and independently of whether the

Patent Claims

1. Method for producing a single crystal by means of the floating zone method, wherein the single crystal crystallizes with the support of an induction heating coil below a melt zone at a crystallization boundary, and the emission of crystallization heat is impeded by a reflector surrounding the single crystal, characterized in that the single crystal is heated in the region of an outer edge of the crystallization boundary by means of a heating device in a first zone, wherein a distance Δ between an outer triple point T_a at the outer edge of the crystallization boundary and a center Z of the crystallization boundary is influenced.

2. Method according to Claim 1, characterized in that the single crystal is heated with the aid of the heating device in such a way that the distance Δ between the outer triple point T_a at the outer edge of the crystallization boundary and the center Z of the crystallization boundary is not more than 90% of a distance Δ' that exists between the outer triple point T_a and the center Z if the heating device is dispensed with.

3. Method according to Claim 1 or Claim 2, characterized in that the electrical power of the induction heating coil is regulated in such a way that a chosen absolute value of a distance H in the melt zone between an inner triple point T_i at an upper end of the melt zone and the outer triple point T_a at the outer edge of the crystallization boundary does not change.

4. Method according to any of Claims 1 to 3, characterized in that the single crystal is heated by means of a radiant heating system as heating

device.

5. Method according to any of Claims 1 to 3, characterized in that the single crystal is heated by means of an induction heating system as heating device.

6. Method according to any of Claims 1 to 5, characterized in that the electrical power of the heating device is controlled in a manner dependent on the length of the single crystal.

7. Method according to any of Claims 1 to 6, characterized in that energy having an electrical power of not less than 2 kW is fed to the single crystal with the aid of the heating device.

8. Method according to any of Claims 1 to 7, characterized in that that region of the single crystal which is heated by means of the heating device has, in the longitudinal direction of the single crystal from the outer triple point T_a a length L that is not longer than the distance Δ.

9. Method according to any of Claims 1 to 8, characterized in that the reflector impedes the emission of crystallization heat in a second zone, which is adjacent to the first zone and which has a length S in the longitudinal direction of the single crystal, wherein the sum of the lengths S and L corresponds to 0.5 to 1.5 times the diameter D of the single crystal.

10. Method according to any of Claims 1 to 9, characterized in that a body surrounding the single crystal and absorbing thermal radiation facilitates the emission of crystallization heat in a third zone, which follows the second zone and which begins at a distance from the outer triple

point T_a which has at least the length of the diameter of the single crystal.

11. Method according to any of Claims 1 to 10, characterized in that the melt zone is formed by continued melting of a polycrystalline feed rod composed of silicon.

12. Method according to any of Claims 1 to 10, characterized in that the melt zone is formed by continued melting of polycrystalline granular silicon.

13. Apparatus for producing a single crystal by means of the floating zone method, comprising a reflector surrounding the single crystal, and a heating device for heating the single crystal in the region of an outer edge of a crystallization boundary of the single crystal.

14. Apparatus according to Claim 13, characterized in that the heating device is a radiant heating system.

15. Apparatus according to Claim 13, characterized in that the heating device is an induction heating system.

16. Apparatus according to any of Claims 13 to 15, characterized in that the heating device is integrated in the reflector.

17. Apparatus according to any of Claims 13 to 16, characterized in that the heating device is dimensioned in such a way that that region of the single crystal which is heated by means of the heating device is, in the longitudinal direction of the single crystal, a first zone, which, from an outer triple point T_a, has a length L that is

not longer than a distance Δ that exists between the outer triple point T_a at the outer edge of the crystallization boundary and a center Z of the crystallization boundary.

18. Apparatus according to any of Claims 13 to 17, characterized in that the reflector impedes the emission of crystallization heat by the single crystal in a second zone, which is adjacent to the first zone and which has a length S in the longitudinal direction of the single crystal, wherein the sum of the lengths S and L corresponds to 0.5 to 1.5 times the diameter D of the single crystal.

19. Apparatus according to any of Claims 13 to 18, characterized by a body surrounding the single crystal and absorbing thermal radiation, said body facilitating the emission of crystallization heat by the single crystal in a third zone, which follows the second zone and which begins at a distance from the outer triple point T_a that has at least the length of the diameter D of the single crystal.

Patent Claims

1. Method for producing a single crystal by means of the floating zone method, wherein the single crystal crystallizes with the support of an induction heating coil below a melt zone at a crystallization boundary, and the emission of crystallization heat is impeded by a reflector surrounding the single crystal, characterized in that the single crystal is heated in the region of an outer edge of the crystallization boundary by means of a heating device in a first zone, wherein a distance Δ between an outer triple point T_a at the outer edge of the crystallization boundary and a center Z of the crystallization boundary is influenced such that the region of the single crystal which is heated by means of the heating device has, in the longitudinal direction of the single crystal from the outer triple point T_a, a length L that is not longer than the distance Δ.

2. Method according to Claim 1, characterized in that the single crystal is heated with the aid of the heating device in such a way that the distance Δ between the outer triple point T_a at the outer edge of the crystallization boundary and the center Z of the crystallization boundary is not more than 90% of a distance Δ' that exists between the outer triple point T_a and the center Z if the heating device is dispensed with.

3. Method according to Claim 1 or Claim 2, characterized in that the electrical power of the induction heating coil is regulated in such a way that a chosen absolute value of a distance H in the melt zone between an inner triple point T_i at an upper end of the melt zone and the outer triple point T_a at the outer edge of the crystallization boundary does not change.

4. Method according to any of Claims 1 to 3, characterized in

that the single crystal is heated by means of a radiant heating system as heating device.

5. Method according to any of Claims 1 to 3, characterized in that the single crystal is heated by means of an induction heating system as heating device.

6. Method according to any of Claims 1 to 5, characterized in that the electrical power of the heating device is controlled in a manner dependent on the length of the single crystal.

7. Method according to any of Claims 1 to 6, characterized in that energy having an electrical power of not less than 2 kW is fed to the single crystal with the aid of the heating device.

8. Method according to any of Claims 1 to 7, characterized in that the reflector impedes the emission of crystallization heat in a second zone, which is adjacent to the first zone and which has a length S in the longitudinal direction of the single crystal, wherein the sum of the lengths S and L corresponds to 0.5 to 1.5 times the diameter D of the single crystal.

9. Method according to any of Claims 1 to 8, characterized in that a body surrounding the single crystal and absorbing thermal radiation facilitates the emission of crystallization heat in a third zone, which follows the second zone and which begins at a distance from the outer triple point T_a which has at least the length of the diameter of the single crystal.

10. Method according to any of Claims 1 to 9, characterized in that the melt zone is formed by continued melting of a polycrystalline feed rod composed of silicon.

11. Method according to any of Claims 1 to 9, characterized in that the melt zone is formed by continued melting of polycrystalline granular silicon.

12. Apparatus for producing a single crystal by means of the floating zone method, comprising a reflector surrounding the single crystal, and a heating device for heating the single crystal in the region of an outer edge of a crystallization boundary of the single crystal, wherein the heating device is dimensioned in such a way that the region of the single crystal which is heated by means of the heating device is, in the longitudinal direction of the single crystal, a first zone, which, from an outer triple point T_a, has a length L that is not longer than a distance Δ that exists between the outer triple point T_a at the outer edge of the crystallization boundary and a center Z of the crystallization boundary.

13. Apparatus according to Claim 12, characterized in that the heating device is a radiant heating system.

14. Apparatus according to Claim 12, characterized in that the heating device is an induction heating system.

15. Apparatus according to any of Claims 12 to 14, characterized in that the heating device is integrated in the reflector.

16. Apparatus according to any of Claims 12 to 15, characterized in that the reflector impedes the emission of crystallization heat by the single crystal in a second zone, which is adjacent to the first zone and which has a length S in the longitudinal direction of the single crystal, wherein the sum of the lengths S and L corresponds to 0.5 to 1.5 times the diameter D of the single crystal.

17. Apparatus according to any of Claims 12 to 16, characterized by a body surrounding the single crystal and absorbing thermal radiation, said body facilitating the emission of crystallization heat by the single crystal in a third zone, which follows the second zone and which begins at a distance from the outer triple point T_a that has at least the length of the diameter D of the single crystal.