CLAIMS:

1. A method for producing a single crystal silicon ingot from a silicon melt held within a crucible comprising:

adding polycrystalline silicon to the crucible;

heating the polycrystalline silicon to cause a first silicon melt to form in the crucible;

pulling a first sample rod from the first silicon melt, the first sample rod having a first sample rod diameter;

measuring a first sample rod parameter related to the quality of the first sample rod and/or the first silicon melt;

pulling a second sample rod from the first silicon melt, the second sample rod having a second sample rod diameter, dopant not being added to the melt before growth of the second sample rod;

measuring a second sample rod parameter related to the quality of the second sample rod and/or the first silicon melt, the first sample rod parameter and the second sample rod parameter being the same parameter; ~~and~~

pulling a first product ingot from the first silicon melt, the first product ingot having a diameter, the first sample rod diameter and the second sample rod diameter being less than the diameter of the first product ingot;

heating polycrystalline silicon in the crucible to cause a second silicon melt to form in the crucible; and

pulling a second product ingot from the second silicon melt, the second product ingot having a diameter, the first sample rod diameter and the second sample rod diameter being less than the diameter of the second product ingot, wherein a growth condition of the second product ingot grown from the second silicon melt is altered based at least in part on a rate of change in a difference between the measured first sample rod parameter and the measured second sample rod parameter.

~~2. The method as set forth in claim 1 wherein the first sample rod parameter and the second sample rod parameter are the same parameter.~~

~~3. The method as set forth in claim 2 further comprising comparing the measured first sample rod parameter to the measured second sample rod parameter.~~

~~4. The method as set forth in claim 3 wherein the change of the parameter over time is measured.~~

~~5. The method as set forth in claim 1 wherein the first sample rod parameter and the second sample rod parameter are different parameters.~~

~~6~~2. The method as set forth in ~~any one of~~ claim~~s~~ 1 ~~to 5~~ wherein the first sample rod parameter and the second sample rod parameter is related to the impurity concentration of the melt and/or product ingot.

~~7~~3. The method as set forth in claim ~~6~~2 wherein the parameter is selected from the group consisting of the phosphorous concentration, boron concentration, aluminum concentration, gallium concentration, arsenic concentration, indium concentration, antimony

concentration, total impurity concentration, dopant concentration, and resistivity of the sample rod.

~~8~~4. The method as set forth in any one of claims 1 to ~~7~~3 wherein polycrystalline silicon is not added to the crucible after the first sample rod is grown.

~~9~~5. The method as set forth in any one of claims 1 to ~~8~~4 wherein the impurity concentration of the first rod and second rod are measured, the concentration of impurities in the first and second rods being less than $1x10^{12}$ atoms/cm^3.

~~10~~6. The method as set forth in claim ~~9~~5 wherein the impurity concentration is measured by Fourier-transform infrared spectroscopy or by photoluminescence.

~~11. The method as set forth in any one of claims 1 to 10 further comprising altering a growth condition of the product ingot based at least in part on the measured first sample rod parameter and/or the measured second sample rod parameter.~~

~~12. The method as set forth in any one of claims 1 to 10 wherein the product ingot is a first product ingot and the melt is a first melt, the method further comprising altering a growth condition of a second product ingot grown from a second melt based at least in part on the measured first sample rod parameter and/or the measured second sample rod parameter.~~

~~13~~7. The method as set forth in any one of claim~~s 11 or claim 12~~1 to 6 wherein the growth condition is selected from the group consisting of a hot-zone configuration, side heater power, heater geometry, crucible

liner thickness, dopant concentration, impurity and dopant evaporation, gas flow rate, and chamber pressure.

~~14~~8. The method as set forth in any one of claims 1 to ~~13~~7 further comprising correlating the measured first sample rod parameter and/or the measured second sample rod parameter to crucible dissolution, hot zone contamination or gas flow impurity.

~~15~~9. The method as set forth in any one of claims 1 to ~~14~~8 wherein the first sample rod parameter and the second sample rod parameter are the resistivity of the sample rod, the first sample rod resistivity and the second sample rod resistivity being measured by contacting the rod with a resistivity probe.

~~16~~10. The method as set forth in claim ~~15~~9 further comprising:

forming a planar segment on the first sample rod, the resistivity of the first sample rod being measured on the planar segment; and

forming a planar segment on the second sample rod, the resistivity of the second sample rod being measured on the planar segment.

~~17~~11. The method as set forth in claim ~~16~~10 wherein each planar segment extends axially from one end of the sample rod toward a second end of the sample rod.

~~18~~12. The method as set forth in any one of claims ~~15~~9 to ~~17~~11 further comprising applying a current to the sample rod to measure a resistance of the sample rod.

~~19~~13. The method as set forth in any one of claims ~~15~~9 to ~~18~~12 wherein each sample rod is secured by a measurement apparatus comprising a clamp that holds the sample rod while contacting the sample rod with a resistivity probe.

~~20~~14. The method as set forth in any one of claims ~~15~~9 to ~~19~~13 further comprising annealing each sample rod in a thermal donor kill cycle prior to measuring a resistivity of the sample rod.

~~21~~15. The method as set forth in any one of claims 1 to ~~20~~14 wherein the diameters of the first and second sample rods are each less than 0.50 times the diameter of the product ingot.

~~22~~16. The method as set forth in any one of claims 1 to ~~21~~15 wherein the first and second sample rods each have a length of less than about 300 mm.

~~23~~17. The method as set forth in any one of claims 1 to ~~22~~16 wherein the product ingot has a resistivity of at least about 1,500 Ω-cm.

~~24~~18. The method as set forth in any one of claims 1 to ~~23~~17 wherein the first and second sample rod each has a resistivity of at least 1,500 Ω-cm.

~~25~~19. A method for modeling the impurity concentration of a single crystal silicon ingot, the method comprising:

pulling a first sample rod from a silicon melt disposed in a crucible, the first sample rod having a first sample rod diameter of less than 100 mm;

measuring a first sample rod parameter related to the impurity content of the first sample rod;

pulling a second sample rod from the silicon melt, the second sample rod having a first sample rod diameter of less than 100 mm;

measuring a second sample rod parameter related to the impurity content of the second sample rod;

determining the impurity concentration of a single crystal silicon ingot based at least in part on a rate of change in the difference between the measured first sample rod parameter and the measured second sample rod parameter.

~~26~~20. The method as set forth in claim ~~25~~19 wherein the first sample rod parameter and the second sample rod parameter is the same parameter, the parameter being selected from the group consisting of the phosphorous concentration, boron concentration, aluminum concentration, gallium concentration, arsenic concentration, indium concentration, antimony concentration, total impurity concentration, dopant concentration, and resistivity of the sample rod.

~~27~~21. The method as set forth in claim ~~25~~19 or claim ~~26~~20 wherein the first sample rod diameter and the second sample rod diameter is each less than about 50 mm.

~~28~~22. The method as set forth in any one of claims ~~25~~19 to ~~27~~21 further comprising:

pulling a third, fourth, fifth, sixth, seventh, eighth, ninth and/or tenth sample rod from the melt, the diameter of each sample rod being less than about 100 mm; and

measuring a sample rod parameter related to the impurity content for each sample rod pulled from the melt.

~~29~~23. The method as set forth in any one of claims ~~25~~19 to ~~28~~22 wherein the impurity concentration of a single crystal silicon ingot is determined from a model, the first sample rod parameter and the second sample rod parameter being input into the model.

~~30~~24. The method as set forth in any one of claims ~~25~~19 to ~~29~~23 further comprising pulling a product ingot from the melt, the single crystal silicon ingot in which the impurity concentration is determined being the product ingot pulled from the melt.

~~31~~25. The method as set forth in any one of claims ~~25~~19 to ~~30~~24 wherein the melt is a first melt, the method further comprising:

pulling a first product ingot from the first melt: and

pulling a second product ingot from a second melt, the single crystal silicon ingot in which the impurity concentration is determined being the second product ingot pulled from the second melt.

~~32~~26. The method as set forth in claim ~~30~~24 or claim ~~31~~25 wherein the diameter of the first and second sample rods are each less than 0.75 times the diameter of the product ingot.

~~33~~27. The method as set forth in any one of claims ~~25~~19 to ~~32~~26 wherein the impurity concentration is an impurity concentration of a portion of the single crystal silicon ingot.

~~34~~28. The method as set forth in any one of claims ~~25~~19 to ~~33~~27 wherein the impurity concentration is concentration of one or more impurities over the length of the single crystal silicon ingot.

~~35~~29. The method as set forth in any one of claims ~~25~~19 to ~~33~~27 further comprising annealing each sample rod in a thermal donor kill cycle prior to measuring the first and second sample rod parameters.