~~WHAT IS CLAIMED IS~~CLAIMS:

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

a housing defining a chamber;

a crucible disposed within the chamber; and

a dopant injector extending into the housing, the dopant injector comprising:

an injection module attached to an outer surface of the housing, the injection module comprising:

a first reservoir for containing a liquid dopant;

a second reservoir for containing the liquid dopant;

a first valve for selectively channeling the liquid dopant from the first reservoir to the second reservoir; and

a second valve for selectively channeling the liquid dopant from the second reservoir to the chamber; and

a delivery module attached to the injection module and extending through the housing into the chamber, wherein the second valve selectively channels the liquid dopant into the delivery module and the delivery module vaporizes the liquid dopant into a vaporized dopant ~~comprising:~~

~~a dopant injection tube positioned within the chamber; and~~

~~a vaporization cup positioned within the dopant injection tube and the chamber, wherein the second valve selectively channels the liquid dopant into the vaporization cup and the vaporization cup vaporizes the liquid dopant into a vaporized dopant~~.

~~2. The ingot puller apparatus as set forth in claim 1 wherein the dopant injection tube includes a first end positioned proximate a surface of a melt to direct the vaporized dopant to the surface.~~

~~3. The ingot puller apparatus as set forth in claim 1 wherein the vaporization cup comprising:~~

~~a receiver; and~~

~~a vaporization plug positioned within the receiver, wherein the liquid dopant is injected onto the receiver and the receiver vaporizes the liquid dopant into the vaporized dopant.~~

~~4. The ingot puller apparatus as set forth in claim 3 wherein the vaporization plug divides the receiver into a liquid reception portion and a vapor channel portion.~~

~~5. The ingot puller apparatus as set forth in claim 4 wherein the receiver defines channels that channel the vaporized dopant from the liquid reception portion to the dopant injection tube.~~

~~6. The ingot puller apparatus as set forth in claim 5 wherein the vaporization plug includes a first end and a second end and defines vapor channels extending from the first end to the second end, wherein the liquid dopant is injected onto the vaporization plug and the vaporized~~

~~dopant is channeled into the channels through the vapor channels.~~

~~7. The ingot puller apparatus as set forth in claim 1 wherein the dopant injector includes a bellows for moving the dopant injection tube proximate the silicon melt.~~

~~8. The ingot puller apparatus as set forth in claim 1 further comprising a heating system for heating the vaporization cup using radiant heat from the heating system, wherein the radiant heat from the heating system is excess heat from the heating system as the heating system melts polycrystalline silicon in the crucible.~~

~~9~~2. An ingot puller apparatus for producing a doped single crystal silicon ingot, the ingot puller apparatus comprising:

a housing defining a chamber;

a crucible disposed within the chamber; and

a dopant injector extending into the housing, the dopant injector comprising:

an injection module attached to an outer surface of the housing, the injection module comprising:

a first reservoir for containing a liquid dopant;

a second reservoir for containing the liquid dopant;

a first valve for selectively channeling the liquid dopant from the first reservoir to the second reservoir; and

a second valve for selectively channeling the liquid dopant from the second reservoir to the chamber; and

a delivery module attached to the injection module and extending through the housing into the chamber, the delivery module comprising:

a dopant injection tube positioned within the chamber; and

a vaporization cup positioned within the dopant injection tube and the chamber, wherein the second valve selectively channels the liquid dopant into the vaporization cup and the vaporization cup ~~delivery module and the delivery module~~ vaporizes the liquid dopant into a vaporized dopant.

3. The ingot puller apparatus as set forth in claim 2 wherein the dopant injection tube includes a first end positioned proximate a surface of a melt to direct the vaporized dopant to the surface.

4. The ingot puller apparatus as set forth in claim 2 further comprising a shaft coupled to the second valve, wherein the shaft actuates second valve.

5. The ingot puller apparatus as set forth in claim 2 wherein the vaporization cup comprises:

a receiver; and

a vaporization plug positioned within the receiver, wherein the liquid dopant is injected onto the

receiver and the receiver vaporizes the liquid dopant into the vaporized dopant.

6. The ingot puller apparatus as set forth in claim 5 wherein the vaporization plug divides the receiver into a liquid reception portion and a vapor channel portion.

7. The ingot puller apparatus as set forth in claim 6 wherein the receiver defines channels that channel the vaporized dopant from the liquid reception portion to the dopant injection tube.

8. The ingot puller apparatus as set forth in claim 7 wherein the vaporization plug includes a first end and a second end and defines vapor channels extending from the first end to the second end, wherein the liquid dopant is injected onto the vaporization plug and the vaporized dopant is channeled into the channels through the vapor channels.

9. The ingot puller apparatus as set forth in claim 2 further comprising a heating system for heating the vaporization cup using radiant heat from the heating system, wherein the radiant heat from the heating system is excess heat from the heating system as the heating system melts polycrystalline silicon in the crucible.

~~10. The ingot puller apparatus as set forth in claim 9 further comprising a shaft coupled to the second valve, wherein the shaft actuates second valve.~~

~~11. The ingot puller apparatus as set forth in Claim 9, wherein the first reservoir and the second reservoir are maintained at a pressure above a pressure of the chamber.~~

~~12. An ingot puller apparatus for producing a doped single crystal silicon ingot, the ingot puller apparatus comprising:~~

~~a housing defining a chamber;~~

~~a crucible disposed within the chamber; and~~

~~a dopant injector extending into the housing, the dopant injector comprising:~~

~~an injection module attached to an outer surface of the housing, the injection module comprising:~~

~~a first reservoir for containing a liquid dopant;~~

~~a second reservoir for containing the liquid dopant;~~

~~a first valve for selectively channeling the liquid dopant from the first reservoir to the second reservoir; and~~

~~a second valve for selectively channeling the liquid dopant from the second reservoir to the chamber; and~~

~~a delivery module attached to the injection module and extending through the housing into the chamber, the delivery module comprising:~~

~~a dopant injection tube positioned within the chamber; and~~

a vaporization cup positioned within the dopant injection tube and the chamber, wherein the second valve selectively channels the liquid dopant into the vaporization cup and the vaporization cup vaporizes the liquid dopant into a vaporized dopant.

13. The ingot puller apparatus as set forth in claim 12 wherein the dopant injection tube includes a first end positioned proximate a surface of a melt to direct the vaporized dopant to the surface.

14. The ingot puller apparatus as set forth in claim 12 further comprising a shaft coupled to the second valve, wherein the shaft actuates second valve.

15. The ingot puller apparatus as set forth in claim 12 wherein the vaporization cup comprising:

a receiver; and

a vaporization plug positioned within the receiver, wherein the liquid dopant is injected onto the receiver and the receiver vaporizes the liquid dopant into the vaporized dopant.

16. The ingot puller apparatus as set forth in claim 15 wherein the vaporization plug divides the receiver into a liquid reception portion and a vapor channel portion.

17. The ingot puller apparatus as set forth in claim 16 wherein the receiver defines channels that channel the vaporized dopant from the liquid reception portion to the dopant injection tube.

18. The ingot puller apparatus as set forth in claim 17 wherein the vaporization plug includes a first end

~~and a second end and defines vapor channels extending from the first end to the second end, wherein the liquid dopant is injected onto the vaporization plug and the vaporized dopant is channeled into the channels through the vapor channels.~~

~~19. The ingot puller apparatus as set forth in claim 12 wherein the dopant injector includes a bellows for moving the dopant injection tube proximate the silicon melt.~~

~~20. The ingot puller apparatus as set forth in claim 12 further comprising a heating system for heating the vaporization cup using radiant heat from the heating system, wherein the radiant heat from the heating system is excess heat from the heating system as the heating system melts polycrystalline silicon in the crucible.~~

~~21~~10. A method for doping a single crystal silicon ingot pulled from a silicon melt held within a crucible positioned within an ingot puller apparatus, the ingot puller apparatus includes a housing, a dopant injector extending into the housing, and a heating system positioned with the housing, the dopant injector including a ~~dopant injection~~feed tube positioned within the housing and a vaporization cup positioned within the ~~dopant injection~~feed tube and the housing, the method comprising:

heating the vaporization cup using the heating system;

maintaining a pressure within~~of an interior of~~ the housing and the feed tube at a first pressure;

injecting liquid dopant into the ~~dopant injection~~feed tube and the vaporization cup, wherein a pressure of the liquid dopant is maintained at a second

pressure greater than the first pressure prior to injection into the ~~dopant injection~~feed tube and the vaporization cup;

vaporizing the liquid dopant into vaporized dopant within the ~~housing~~feed tube, wherein the liquid dopant is vaporized by flash evaporation by heating the liquid dopant with the vaporization cup and reducing the pressure of the liquid dopant from the second pressure to the first pressure by injecting the liquid dopant into the ~~housing~~feed tube; and

channeling the vaporized dopant ~~into the housing~~towards the silicon melt using the ~~dopant injection~~feed tube.

~~22~~11. The method as set forth in claim ~~21~~10, wherein heating the vaporization cup comprises heating the vaporization cup using radiant heat from the heating system, wherein the radiant heat from the heating system is excess heat from the heating system as the heating system melts polycrystalline silicon in the crucible.

~~23. The method as set forth in claim 21 further comprising channeling an inert gas into the dopant injection tube, wherein the inert gas channels the vaporized dopant into the housing.~~

~~24. The method as set forth in claim 21, wherein the first pressure is a pressure below atmospheric pressure.~~

~~25~~12. The method as set forth in claim ~~21~~10, wherein the first pressure is a vacuum and the second pressure is atmospheric pressure.

~~26~~13. The method as set forth in claim ~~21~~10 further comprising diffusing the vaporized dopant into the silicon melt.

~~27~~14. The method as set forth in claim ~~21~~10, wherein the vaporization cup includes a receiver and a vaporization plug positioned within the receiver, and wherein heating the vaporization cup using the heating system comprises heating the vaporization plug positioned within the receiver.

~~28~~15. A method for producing a single crystal silicon ingot from a silicon melt held within a crucible positioned within an ingot puller apparatus, the ingot puller apparatus including a dopant injector extending into a housing of the ingot puller apparatus, the dopant injector including a feed tube positioned within the housing and a vaporization cup positioned within the feed tube and the housing, the method comprising:

adding polycrystalline silicon to the crucible~~, the crucible being disposed within an ingot puller inner chamber~~;

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

pulling ~~a~~the single crystal silicon ingot from the silicon melt;

injecting a liquid dopant into the ~~ingot puller apparatus~~feed tube;

vaporizing the liquid dopant into a vaporized dopant within the ~~ingot puller apparatus~~feed tube by:

heating the liquid dopant using the vaporization cup; and

reducing a pressure of the liquid dopant by injecting the liquid dopant into the feed tube, wherein the housing and the feed tube are maintained at a pressure below atmospheric pressure; and

contacting the vaporized dopant with a surface of the silicon melt to cause the vaporized dopant to enter the silicon melt as a dopant while pulling the single crystal silicon ingot from the silicon melt.

~~29. The method as set forth in claim 28, wherein the ingot puller apparatus includes a dopant injector extending into a housing of the ingot puller apparatus, the dopant injector including a dopant injection tube positioned within the housing and a vaporization cup positioned within the dopant injection tube and the housing, wherein vaporizing the liquid dopant into a vaporized dopant within the ingot puller apparatus comprises:~~

~~heating the liquid dopant using the vaporization cup; and~~

~~reducing a pressure of the liquid dopant by injecting the liquid dopant into the housing, wherein the housing is maintained at a pressure below atmospheric pressure.~~

~~30~~16. The method as set forth in claim ~~29~~15, wherein the dopant injector includes a first reservoir, a first valve, a second reservoir, and a second valve, wherein injecting a liquid dopant into the ~~ingot puller apparatus~~feed tube comprises:

channeling the liquid dopant from the first reservoir to the second reservoir by opening the first valve; and

channeling the liquid dopant from the second reservoir to the ~~housing~~feed tube by opening the second valve.

~~31~~17. The method as set forth in claim ~~29~~16, wherein the dopant injector includes a bellows, wherein ~~injecting a liquid dopant into the ingot puller apparatus~~the method comprises:

moving the ~~dopant injection~~feed tube proximate the silicon melt using the bellows;

channeling the vaporized dopant towards the silicon melt using the feed tube proximate the silicon melt such that the vaporized dopant contacts the surface of the silicon melt; and

diffusing the vaporized dopant into the silicon melt.

~~32. The method as set forth in claim 29 further comprising heating the vaporization cup using radiant heat from a heating system, wherein the radiant heat from the heating system is excess heat from the heating system as the heating system melts polycrystalline silicon in the crucible.~~

~~33. The method as set forth in claim 29 further comprising channeling an inert gas into the dopant injection tube, wherein the inert gas channels the vaporized dopant into the housing.~~

~~34. The method as set forth in claim 29, wherein the first reservoir and the second reservoir are maintained at a pressure above the pressure of the housing.~~

~~35. The method as set forth in claim 34, wherein the pressure of the housing is a vacuum and the first reservoir and the second reservoir is atmospheric pressure.~~

~~36. The method as set forth in claim 29, wherein the vaporization cup includes a receiver and a vaporization plug positioned within the receiver, and wherein heating the liquid dopant using the vaporization cup comprises:~~

~~heating the vaporization plug positioned within the receiver; and~~

~~heating the liquid dopant using the vaporization plug.~~

~~37~~18. A method for doping a single crystal silicon ingot pulled from a silicon melt held within a crucible positioned within an ingot puller apparatus, the ingot puller apparatus includes a housing, a dopant injector extending into the housing, and a heating system positioned with the housing, the dopant injector including a ~~dopant injection~~feed tube positioned within the housing and a vaporization cup positioned within the ~~dopant injection~~feed tube and the housing, the method comprising:

heating the vaporization cup using the heating system;

injecting liquid dopant into the ~~dopant injection~~feed tube and the vaporization cup;

vaporizing the liquid dopant into vaporized dopant within the ~~housing~~feed tube, wherein the liquid dopant is vaporized by flash evaporation by heating the liquid dopant with the vaporization cup at a pressure that is below atmospheric pressure; and

channeling the vaporized dopant towards the silicon melt~~into the housing~~ using the ~~dopant injection~~feed tube.

~~38~~19. The method as set forth in claim ~~37~~18, wherein heating the vaporization cup comprises heating the vaporization cup using radiant heat from the heating system, wherein the radiant heat from the heating system is excess heat from the heating system as the heating system melts polycrystalline silicon in the crucible.

~~39~~20. The method as set forth in claim ~~38~~19, wherein the dopant injector includes a first reservoir, a first valve, a second reservoir, and a second valve, wherein injecting ~~a~~the liquid dopant into the ~~ingot puller apparatus~~feed tube comprises:

channeling the liquid dopant from the first reservoir to the second reservoir by opening the first valve; and

channeling the liquid dopant from the second reservoir to the ~~housing~~feed tube by opening the second valve.

~~40. The method as set forth in claim 37, wherein the vaporization cup includes a receiver and a vaporization plug positioned within the receiver, and wherein heating the liquid dopant using the vaporization cup comprises:~~

~~heating the vaporization plug positioned within the receiver; and~~

~~heating the liquid dopant using the vaporization plug.~~