

Apparatus for pulling a single crystal of semiconductor material by the CZ method from a melt and method using the apparatus

5 The invention provides an apparatus and for the use thereof for pulling of a single crystal of semiconductor material by the CZ method from a melt. The apparatus comprises a crucible to accommodate the melt, a resistance heater arranged around the crucible, a camera system for observing a phase boundary between the melt and the growing single crystal, and a heat shield in frustoconical form with narrowing
10 diameter in the region of its lower end and arranged above the crucible and surrounding the single crystal.

Prior art / problems

EP 2 031 100 A1 describes an apparatus having the features mentioned above and a
15 method of producing a single crystal by the CZ method in which the apparatus is used.

US 5 919 303 describes a method of recharging silicon, wherein the crucible is recharged with polycrystalline silicon in the form of granules.

20 JP2001-3978 A discloses a heat shield additionally having an inner cylinder to stop particles of silicon oxide (SiO) from falling into the melt. If such particles get into the growing single crystal, they can cause dislocations and make the single crystal unusable for the intended use. A disadvantage of this heat shield is that it hinders a
25 clear view to the phase boundary between the melt and the growing single crystal.

It is an object of the present invention to propose an apparatus having the features mentioned at the outset, the use of which can largely stop unwanted particles from getting into the melt without any associated disadvantage.

30

The object of the invention is achieved by an apparatus for pulling a single crystal of semiconductor material by the CZ method from a melt, comprising a crucible to accommodate the melt;

a resistance heater arranged around the crucible;
a camera system for observing a phase boundary between the melt and the growing single crystal, where the camera system has an optical axis; and
a heat shield in frustoconical form with narrowing diameter in the region of its lower end and arranged above the crucible and surrounding the growing single crystal,
5 characterized by
an annular element for capturing particles that projects inward from an inner side face of the heat shield and has an arrestor edge directed upward at its inner end, wherein the optical axis of the camera system runs between the arrestor edge and the growing
10 single crystal.

Particles that can disrupt or terminate single-crystal growth of a crystal of semiconductor material form not only in the resubliming of SiO but especially also in the recharging of semiconductor material, especially in the form of abraded material
15 that comes from the heat shield. The present invention ensures that dislocation events become less common and that the concentration of extraneous elements that originate from particles and are dissolved in the melt, especially the concentration of carbon, becomes lower.

20 The apparatus of the invention comprises a heat shield extended by an annular element that captures particles which, without its presence, would fall into the crucible. The annular element projects inward from an inner side face of the heat shield, i.e. in the direction of the growing single-crystal, and has a cross-sectional area having an arrestor edge (trapping enclosure) that projects upward at its inner end. Particles are
25 captured between the arrestor edge and the heat shield. The annular element projects toward the growing single crystal, and the optical axis of the camera system runs between the arrestor edge and the growing single crystal. In other words, the optical axis does not meet either the heat shield or the annular element or its arrestor edge.

30 The heat shield is, entirely or at least in the region of its lower end, in frustoconical form with narrowing diameter.

It is preferable to secure the annular element to the heat shield in such a way as to maintain a distance between the annular element and the lower end of the heat shield. This distance is preferably 10 mm to 100 mm.

- 5 The annular element is preferably releasably connected to the heat shield. It preferably consists of the same material as the inner lateral face of the heat shield.

The arrestor edge projects from the inner end of the annular element upward, preferably over a distance of not less than 2 mm and not more than 100 mm. In
10 addition, the arrestor edge is preferably inclined outward, i.e. inclined toward the heat shield.

The invention additionally also provides a method of pulling a single crystal of semiconductor material in an apparatus of the invention,
15 comprising the charging of the crucible with solid semiconductor material;
the melting of a portion or the entire mass of the solid semiconductor material;
the further charging of the crucible with further solid semiconductor material;
the heating of the crucible contents until they have melted completely; and
the pulling of the single crystal by the CZ method.
20
The semiconductor material preferably consists of silicon, germanium or a mixture of the two elements.

The growing single crystal comprises a cylindrical section having a diameter of at
25 least 200 mm, preferably at least 300 mm.

The features specified with regard to the above-detailed embodiments of the method of the invention can be applied correspondingly to the apparatus of the invention. Conversely, the features specified with regard to the above-detailed embodiments of
30 the apparatus of the invention can be applied correspondingly to the method of the invention. These and other features of the embodiments of the invention are elucidated in the description of the figures and in the claims. The individual features can be implemented as embodiments of the invention either separately or in

combination. In addition, they can describe advantageous executions that are independently protectable.

The invention is elucidated hereinafter with reference to drawings.

5

Brief description of the figures

Fig. 1 and **fig. 3** each show an apparatus for pulling a single crystal of semiconductor material by the CZ method, comprising the features of the invention.

10 **Fig. 2** shows a detail of a heat shield connected to an annular element of the invention.

List of reference numerals used

15	1	pulling chamber
	2	crucible
	3	melt
	4	camera system
	5	single-crystal
20	6	shaft
	7	resistance heater
	8	pulling mechanism
	9	heat shield
	10	annular element
25	11	arrestor edge
	12	optical axis
	13	lower end

The apparatus according to fig. 1 comprises a pulling chamber 1 in which there is
 30 situated a crucible 2 for accommodating the melt 3, and a camera system 4 for observing a phase boundary between the melt 3 and a growing single crystal 5. The crucible 2 is borne by a shaft 6 that can be raised, lowered and turned. Around the crucible 2 is arranged a resistance heater 7, with the aid of which solid semiconductor

material is melted to form the melt 3. The single crystal 5 is pulled from the melt via a pulling mechanism 8. A heat shield 9 that surrounds the single crystal 5 is disposed above the crucible 2. The heat shield 9 is in frustoconical form with narrowing diameter in the region of its lower end. Between the growing single crystal 5 and the inner side face of the heat shield 9 there is an annular element 10 for capturing particles which is connected to the heat shield 9. The annular element 10 projects inward from the inner side face of the heat shield 9 (in the direction of the growing single crystal) and has, at its inner end, an arrestor edge 11 (fig. 2) directed upward. The arrestor edge 11 is formed by a wall closed to form a tube. According to the invention, the annular element 10 and its arrestor edge 11 are formed such that they do not obstruct the optical axis 12 of the camera system 4, meaning that the optical axis 12 runs between the arrestor edge 11 and the growing single crystal 5.

The apparatus according to fig. 3, by contrast with the apparatus according to fig. 1, comprises a heat shield 9 formed with narrowing diameter only in the region of its lower end. In the region above that it has a cylindrical shape.

Fig. 2 shows a detail of the annular element 10 and of the heat shield 9 in cross section. In the embodiment shown, the annular element 10 has a certain distance from the lower end 13 of the heat shield 9 and the arrestor edge 11 is inclined toward the heat shield 9.

The above description of illustrative embodiments should be considered by way of example. The disclosure thus made firstly enables the person skilled in the art to comprehend the present invention and the associated advantages, and secondly, within the understanding of the person skilled in the art, also encompasses obvious alterations and modifications to the structures and methods described. Therefore, all such alterations and modifications and equivalents shall be covered by the scope of protection of the claims. For example, the apparatus may also comprise one or more coils that produce a magnetic field that acts on the melt.

CLAIMS

1. An apparatus for pulling a single crystal of semiconductor material by the
 5 Czochralski (CZ) method from a melt, the apparatus comprising:
 a crucible configured to accommodate the melt;
 a resistance heater arranged around the crucible;
 a camera system for observing a phase boundary between the melt and a
 growing single crystal, where the camera system has an optical axis;
 10 a heat shield in frustoconical form with a narrowing diameter in a region of a
 lower end of the heat shield and arranged above the crucible and surrounding the
 growing single crystal; and
 an annular element, which is configured to capture particles, that projects
 inward from an inner side face of the heat shield and has an arrestor edge directed
 15 upward at an inner end of the annular element,
 wherein the optical axis of the camera system runs between the arrestor edge
 and the growing single crystal, and
 wherein the annular element is releasably connected to the heat shield and
 consists of a same material as the inner side face of the heat shield.
 20
2. The apparatus as claimed in claim 1, wherein the annular element is at a distance
 from the lower end of the heat shield.
3. The apparatus as claimed in claim 2, wherein the distance is 10 mm to 100 mm.
 25
4. The apparatus as claimed in claim 1, wherein the arrestor edge is in an inclined
 arrangement relative to the heat shield.
5. A method of pulling a single crystal of semiconductor material in the apparatus as
 30 claimed in claim 1, the method comprising:
 charging the crucible with solid semiconductor material;
 melting a portion or an entire mass of the solid semiconductor material;
 further charging the crucible with further solid semiconductor material;

heating the crucible contents until the crucible contents have melted completely; and
pulling the single crystal by the CZ method.

- 5 6. The apparatus of claim 1, wherein the annular element is the only element that is configured to capture particles, projects inward from the inner side face of the heat shield, and has the arrestor edge directed upward.
7. The apparatus of claim 1,
- 10 wherein the heatshield is uniform in shape around a central axis,
wherein the annular element has a projecting element that projects inward from the inner side face of the heat shield orthogonal to the central axis, and
wherein the arrestor edge is formed by a second projecting element that projects upward from an inner end of the projecting element and outward toward the
15 inner side face of the heat shield.
8. The apparatus of claim 7, wherein a space for collecting the particles is defined on three sides by an inner face of the second projecting element, an upper face of the first projecting element, and the inner side face of the heat shield.