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Process and device for reducing the load on a seed crystal

5 The invention relates to a process and to a device for reducing the load on a seed crystal during the pulling of a single crystal according to the Czochralski method. The process is used, in particular, for the production of single crystals from silicon or compound semiconductors for electronic purposes. During the process, a seed crystal which is dipped into a melt is
10 pulled away from the melt with the aid of a pulling device, while a single crystal grows on its underside. During pulling, care is taken that a so-called neck with comparatively small diameter is first produced, so that the single crystal can be pulled without dislocations.
15 The single crystal comprises a conical section with increasing diameter at its start, a cylindrical section with almost constant diameter in its middle, and a conical section with decreasing diameter at its end. Only the cylindrical section is usually of interest as a basic
20 product for the electronics industry.

US-4,973,518 has already disclosed that, in particular, the neck can become axially loaded with a comparatively heavy weight when the single crystal is being pulled. However, the application of any transverse
25 force should be avoided since there is a risk of the neck breaking even under slight loading. To avoid this risk, it is proposed to pull the conical section in such a way that it is diametrically widened at an axial position and forms a bulge, where the single crystal can be supported
30 with a gripping device.

The process has disadvantages, in particular, as regards the production of single crystals which have diameters of ≥ 200 mm in the cylindrical section. For example, the material needed to produce the bulge cannot
35 be used for electronic purposes. Further, it is not straightforward for the special shape to be pulled, and if the bulge is not successfully given an exact



rotationally symmetric shape, then the possibility of the neck being loaded by transverse forces cannot absolutely be ruled out when the gripping device is engaged. Even if this does not cause the neck to break, there is a risk that the axis of rotation of the single crystal will be shifted and the cylindrical section will no longer grow straight.

The object of the present invention is to avoid the problems presented above and to achieve the result that, in particular, even comparatively heavy single crystals can also be pulled.

The invention relates to a process for reducing the load on a seed crystal during the pulling of a single crystal by means of a pulling device, wherein an adhesive bond is made between a conical section at the start of the single crystal and a retaining body, and the load on the seed crystal is reduced by creating a tensile stress between the retaining body and the pulling device.

The invention also makes it possible to pull heavy single crystals whose weight is in excess of the loading limit of the neck for axial loads. Since, when the invention is employed, the single crystal is loaded only parallel to its longitudinal axis, problems produced by transverse loading are excluded.

The invention also relates to a device for reducing the load on a seed crystal during the pulling of a single crystal from a melt by means of a pulling device, which comprises a retaining body and an adhesive bond between the retaining body and a conical section at the start of the single crystal, and an arrangement for creating a tensile stress between the retaining body and the pulling device.

The invention will be explained in more detail below with the aid of a figure. The figure shows a schematic sectional representation of a preferred embodiment of the device in side view. Only the features of the device needed for understanding the invention are represented.

The pulling device used is a pulling shaft 1



which has a holder 2 in which a seed crystal 3 is clamped. According to the representation, the neck 4 and the conical section 5 at the start of the single crystal have already been pulled. There is an adhesive bond 7
5 between the surface of the conical section 5 and the retaining body 6. According to the preferred embodiment which is represented, the retaining body has a hollow cylindrical shape and is enclosed by a sealing ring 8 which likewise bears on the surface of the conical
10 section. The sealing ring seals a gap 9 which is filled with the adhesive bond. Between the retaining body 6 and the pulling shaft 1 there is a connection which can be shortened and is provided by an axially movable rod system 10. The rod system is anchored at one end in the
15 pulling shaft and connected at one end to the retaining body.

When the single crystal is pulled, the conical section 5 at the start of the single crystal is firstly allowed to be pulled until its surface area is large
20 enough for an adhesive bond to be made between the conical section and the retaining body 6. The conical section needs to be cooled to a specific temperature T_1 which is tailored to the properties of the material from which the adhesive bond is to be made. Substances, such
25 as glass, glass reinforced with glass fibers, germanium and silver which set as a function of temperature are particularly suitable. This material is brought into contact with the surface of the conical section. The temperature T_1 must be high enough for the material to
30 become liquid or at least soft as a result of the contact. The sealing ring 8 is provided in order to prevent liquid material from passing over the shoulder of the conical section into the melt. The sealing ring is lowered together with the retaining body to the surface
35 of the conical section, until it touches, in which case it may soften in the contact region. The sealing ring is preferably made of glass or glass reinforced with glass fibers. After the sealing ring has been put on, there is a gap 9 between the surface of the conical section and



the retaining body, and this gap is filled with the adhesive bond 7. The material used for the adhesive bond, for example germanium granules, is applied to the surface of the conical section, where it liquefies and penetrates the gap which is sealed off from the outside.

The use of a sealing ring may be omitted if, although becoming soft on contact with the single crystal, the material used for the adhesive bond still remain too viscous to leave the contact region. In this case, the retaining body lowered to the surface of the conical section is one which, overall or at least wherever contact is made with the surface of the conical section, is made of a material that is suitable for the adhesive bond.

As the pulling of the single crystal continues, the conical section cools further, and the material for the adhesive bond sets. When the conical section has cooled to a temperature $T_2 < T_1$, the load on the seed crystal can be reduced. To do this, the rod system 10 is raised and a tensile stress is created, which counteracts the force due to the weight of the single crystal. The magnitude of this tensile stress is expediently increased during the pulling of the single crystal as a function of the increasing single crystal mass.



Patent Claims:

1. A process for reducing the load on a seed crystal during the pulling of a single crystal by means of a pulling device, wherein an adhesive bond is made between
5 a conical section at the start of the single crystal and a retaining body, and the load on the seed crystal is reduced by creating a tensile stress between the retaining body and the pulling device.
2. The process as claimed in claim 1, wherein the
10 adhesive bond is made when the conical section of the single crystal is cooled to a temperature T_1 , and the tensile stress is created when the conical section is cooled to a temperature T_2 .
3. The process as claimed in claim 1 or claim 2,
15 wherein the tensile stress is increased as a function of the single crystal mass that grows as the single crystal is pulled.
4. A device for reducing the load on a seed crystal during the pulling of a single crystal from a melt by
20 means of a pulling device, which comprises a retaining body and an adhesive bond between the retaining body and a conical section at the start of the single crystal, and an arrangement for creating a tensile stress between the retaining body and the pulling device.
- 25 5. The device as claimed in claim 4, wherein the adhesive bond consists of a material which is selected from a group comprising glass, glass reinforced with glass fibers, germanium and silver.
6. The device as claimed in claim 4 or 5, wherein
30 the retaining body has a hollow cylindrical shape.
7. The device as claimed in one of claims 4 to 6, which comprises a sealing ring which is placed on the starting cone and seals a gap between the conical section and the retaining body, the gap serving to accommodate
35 the adhesive bond.
8. The device as claimed in one of claims 4 to 7, wherein the pulling device comprises a pulling shaft, and the arrangement for creating a tensile stress comprises



a rod system which can be moved parallel to the longitudinal axis of the single crystal and connects the retaining body and the pulling shaft.

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