United States Patent

[11] 3,615,262

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[21] Appl. No. **762,992**
[22] Filed **Sept. 26, 1968**
[45] Patented **Oct. 26, 1971**

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[32] Priority **Oct. 4, 1967**
[33] **Germany**
[31] **S 112259**

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[54] **CRYSTAL SEED FOLLOWING A HYPERCYCLOID PATH IN MELT**
5 Claims, 1 Drawing Fig.

[52] **U.S. Cl.** ..... **23/301 SP**
[51] **Int. Cl.** **B01j 17/18**
[50] **Field of Search** ..... 23/273 SD, 301 SP; 33/27 J

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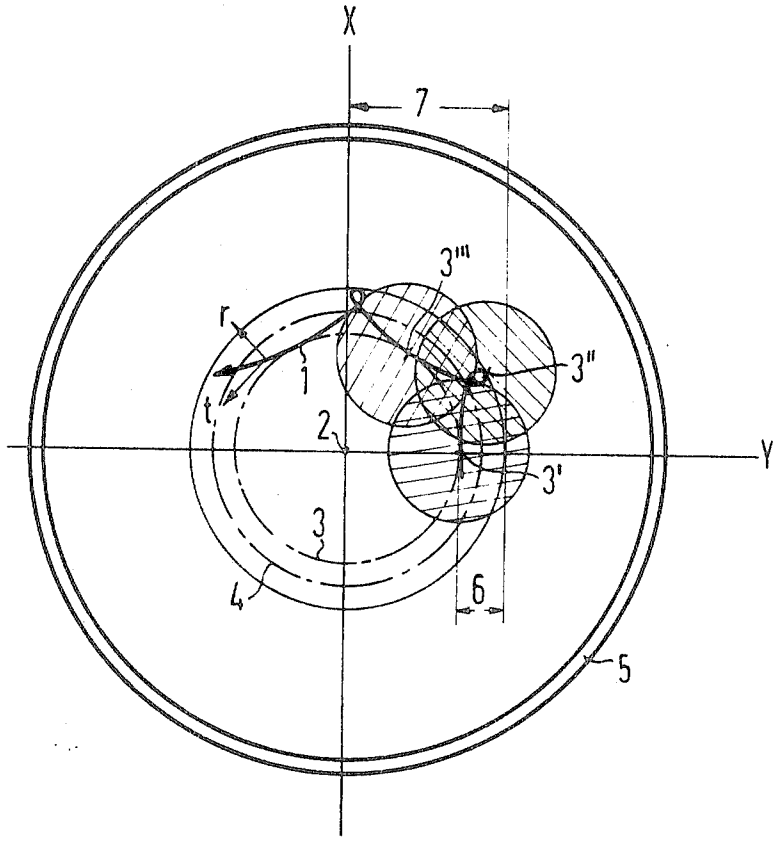
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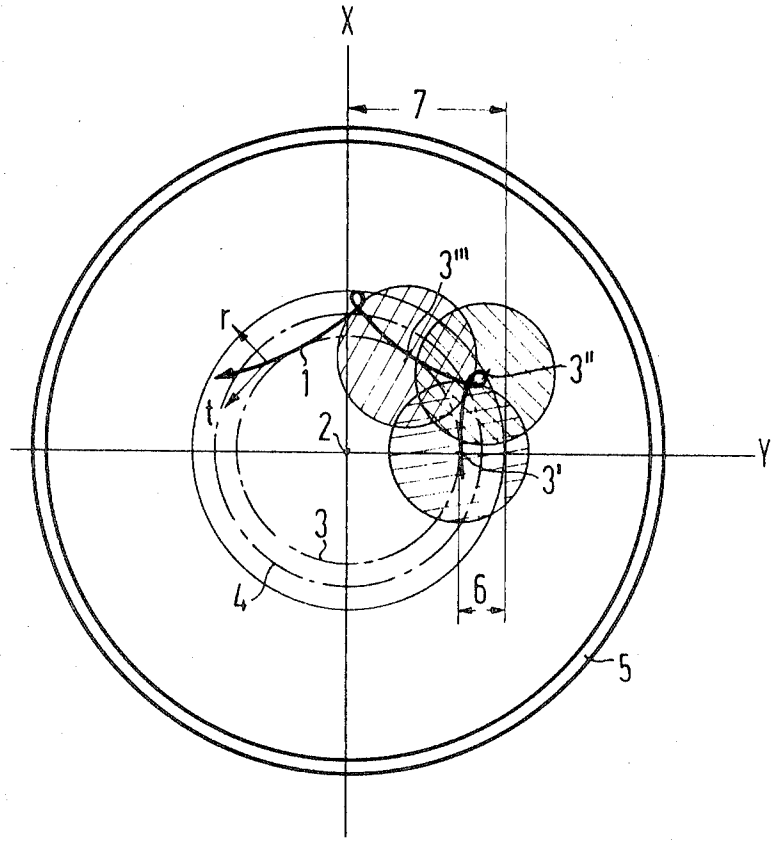
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ABSTRACT: Described is a method of producing a monocrystal rod, which is vertically held at its end, with homogeneous or almost homogeneous doping, by pulling from a crucible according to the Czochralski method. The holder of the seed crystal, which is immersed into the melt, is given an eccentric movement with respect to the melt contained in the crucible. According to the invention the holder of the seed crystal which moves along the eccentric path is given an additional movement which produces a hypercycloid path with respect to the melt.




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CRYSTAL SEED FOLLOWING A HYPERCYCLOID PATH IN MELT

The invention relates to a method for producing a monocrystalline rod, vertically held at one end and having a homogeneous or almost homogeneous doping, by pulling from a melt within a crucible in accordance with the Czochralski method. The holder of the crystal seed, which is immersed into the melt is given an eccentric movement with respect to the melt.

The eccentric pulling method produces, in the crucible pulled monocrystals, a considerable reduction in the resistance change across the crystal cross section, compared to the conventional Czochralski method. The relatively still high number of seed crystals in the order of approximately 100 r.p.m. also influences the crystal quality because of the increased oxygen content in the melt.

Our invention has among its objects the obtainment of an improved crystal quality, together with a relatively uniform radial resistance distribution across the entire rod cross section.

Hence, the present invention relates to an improvement of the known eccentric crucible-pulling method and calls for the holder of the seed crystal which moves along the eccentric path to be given an additional movement which produces a hypercycloid path with respect to the melt.

This feature results in the fact that, by contrast to the simple, eccentric pulling, i.e. a circular path, with resulting one-dimensional mixing, the use of the hypercycloid path results in a two-dimensional mixing of the melt causing a homogeneous distribution of the doping material across the melt volume. The additional mixing effect helps to eliminate high numbers of seed crystals, which are known to make control of the monocrystal growth more difficult and which lead to a higher oxygen content in the melt.

According to a particularly preferred embodiment of our invention, the rotation of the seed crystal is set at 5 to 10 r.p.m. The good mixing of the melting zone moreover ensures a homogeneous temperature curve within the melting zone, so that the resolidified rod crystallizes without high-thermal stresses, and acccordingly, considerably reduces the frequency of crystal disturbances.

It lies within the scope of the present invention to adjust the maximum eccentricity of the seed crystal, i.e. the deviation of the seed crystal axis from the average axis of the crucible, approximately to the size of the rod diameter of the pulled crystal. A semiconductor crystal rod has a normal diameter of about 20 to 25 mm.

According to a particularly preferred embodiment of the invention, the change in eccentricity amounts to about ±4 mm.

It is particularly preferable for the pulling velocity of the crystal from the melt to be between 1 to 3 mm./min.

The method of the present invention makes it possible to produce semiconductor crystal rods, preferably silicon monocrystal rods, with a relatively uniform radial resistance distribution across the rod cross section and with greater crystal perfection than according to the known crucible-pulling method.

The single FIG. of the drawing illustrates the invention. The invention will be described with respect to an embodiment example illustrated by the drawing which, for the sake of clarity, is drawn at an intersection of axes. The curve 1 illustrates the path of the moving crystal seed, caused by the additional movement exerted upon the crystal holder, and includes a tangential component *t* and a radial component *r*. The rotary crucible axis is shown at 2, with the concentric circles, around said axis 2 indicating the crystal seed axis 3, the crystal pulling axis 4 and the crucible edge 5. The double arrow 6 indicates the change of eccentricity, while the double arrow 7 denotes the maximum eccentricity. The hatched circles show a top view of the crystal seed, in sequential phases of movement. The center points of the crystal seed axes, which correspond to the individual phases are marked 3', 3'' and 3'''. The connection of these center points results in the aforementioned path 1 of the crystal seed. This path, in accordance with the present invention, is effected by the additional movement upon the crystal holder. The execution of the method is effected by using conventional driving equipment.

We claim:

1. In the method of producing a monocrystal rod vertically held at its end, with substantially homogeneous doping, by pulling from a crucible according to the Czochralski method, wherein the holder of the seed crystal dipped into the melt is given an eccentric movement with respect to the melt contained in the crucible, the improvement which comprises giving the holder of the seed crystal, with the seed crystal therein, which moves along the eccentric path, an additional movement which produces a hypercycloid path with respect to the melt.

2. The method of claim 1, wherein the maximum eccentricity of the seed crystal is approximately the magnitude of the rod diameter of the pulled crystal.

3. The method of claim 2, wherein the change of the eccentricity is approximately ±4 mm.

4. The method of claim 3, wherein the seed crystal is rotated at 5 to 10 r.p.m.

5. The method of claim 4, wherein the pulling velocity is 1 to 3 mm. per min.