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On factors influencing the cross-section of single crystals automatically pulled from melt

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Effect of the crystallization front shape changes on the maintaining accuracy of the diameter of growing single crystal being pulled automatically from melt has been studied. An equation has been derived providing the determination of the deviation extent of the growing crystal cross-section from the preset value as a function of the volume change rate of the immersed crystal part and/or of the parasite crystallization rate within the bulk melt as well as of the diameter ratio between the crystal and the free melt surface. The front shape change during the growing has been shown to cause no significant changes of the crystal diameter in most practical cases.

Исследовано влияние изменения формы фронта кристаллизации на точность поддержания диаметра растущего монокристалла при автоматизированном вытягивании его из расплава. Получено уравнение, позволяющее определить степень отклонения поперечного сечения растущего кристалла от заданного сечения в зависимости от скорости изменения объема подрасплавной части кристалла и/или паразитной кристаллизации в объеме расплава, а также от соотношения диаметров кристалла и зеркала расплава. Показано, что изменение формы фронта в процессе роста не приводит к значительному изменению диаметра кристалла в большинстве практических случаев.

When single crystals are grown by continuous automated pulling from melt using the melt level sensor [1] and the melt consumption one [2], it is just the stability of the pulling speed and that of the feeding mass rate that are the main factors influencing the crystal diameter maintaining accuracy. This follows from the material balance equations and is confirmed in experiment. The experience in pulling of large alkali halide crystals shows, however, that although of that the above-mentioned are stabilized and the automated system operates correctly, the growing crystal diameter sometimes deviates from its preset value. The following three cases are observed most often: (i) the diameter decreases by 2 or 3 % substantially immediately after the stage of the height growth starts and then, 2 to 3 h later (when the cylindrical crystal part height attains 15 to 20 mm), becomes restored; (ii) the crystal diameter decreases by the same 2 or 3 % during the whole growth process; (iii), the crystal diameter increases monotonously by the same value during the whole growth process. One cause of such crystal diameter change consists in change of the crystal part immersed in the melt. The volume change in the course of growth depends on variations occurring in the heat withdrawal conditions, in the crystal surface reflectance due to sublimated salt layer, in the crystal absorption coefficient in IR region, in the temperature field within the melt, in the melt hydrodynamics, etc.

In [3], an attempt was made to take into account the effect of the crystallization front shape variations on the crystal diameter being pulled automatically under the diameter monitoring basing on the melt level variation. In that work, a simplified ap-