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Numerical modelling of Inductor Optimization for Silicon Crystal Growth with Pedestal Method

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Extended Abstract

The pedestal method [1] is a method of crystal growth, where the feed material is melted from above by high-frequency inductor, and the grown crystal is pulled from a molten zone that is located on top of the feed material (pedestal). An advantage of this method is the absence of contact between the molten material and other system parts. Another advantage is its relative simplicity in comparison with another crucible-free method – the well-known floating zone method, where the feed material is located above the inductor, and thus it is harder to control the melting front. For silicon crystal growth, the pedestal method can be cost-effective in comparison with the floating zone method, if large diameter polycrystalline rods are available [2].

In the present work, the pedestal method is modelled numerically [3]. High-frequency electromagnetic field from the main inductor and middle-frequency field from the additional side inductor are simulated. Then the shape of the phase boundaries is calculated by solving heat transport equation and moving the melting and crystallization interfaces according to heat balance. The numerical model is based on the previous model, first introduced for floating zone method [4]. To get the most desirable shape of phase boundaries (e.g., high distance between the melting and crystallization interfaces), high-frequency inductor optimization is performed with the algorithm of gradient descent.

The most recent results include the consideration of meniscus angle of the free melt surface in the algorithm's target function. In other words, process stability is dependent not only on preventing the collision between the grown crystal and the pedestal, but also on preventing the melt spilling over the pedestal rim. Another novelty of the study is the inclusion of the side inductor power into the set of input parameters for the gradient descent. In the results of the study, several shapes of high-frequency inductor are obtained and compared for different diameters of crystal and pedestal.

The obtained results are helping to increase the diameter of silicon crystals that can be grown from pedestal in the experiments. It could make the pedestal method more efficient, because the larger crystal diameter is, the more electronical schemes can be simultaneously produced from one crystal wafer.

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