CZ シリコン結晶引き上げ過程における成長界面形状の動的予測

Dynamic prediction of the growth interface shape during the pulling process of Czochralski silicon crystal growth

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Magnetic-field-applied Czochralski silicon crystal growth (MCZ-Si) has been established as a standard method to optimize the crystal growing process. The m–c interface shape is coupled with the dynamic melt convection, as well as the segregations of impurities and dopants during the pulling process. Therefore, transient global modeling of the CZ-Si crystal growth process is essential for understanding the dynamic behaviors of the heat and mass transport in MCZ-Si set-up.

The transient global model for the crystal pulling process was developed for CZ-Si growth with the cusp-shaped magnetic field (CMF) [1]. Heat transfer by solid conduction, melt convection, and diffuse grey radiation is taken into account for the crystal, melt and other components in the furnace. The applied CMF suppressed the turbulent melt flow and stabilized the heat and mass transport. The dynamic m–c interface shapes were predicted for the different crystal lengths (CL), as shown in Fig. 1. The convexity m–c interface to the crystal side increased with the increase of the crystal lengths. The effects of the zero-Gauss plane (ZGP) locations of CMF on the convexity m–c interface were also investigated by the transient global simulations, as shown in Fig. 2. The exposure of the m–c interface in the stronger vertical magnetic field resulted in the higher convexity during the pulling process. Furthermore, the dynamic v/G ratio at the m–c interfaces were predicted and discussed for the MCZ-Si crystal growth processes.

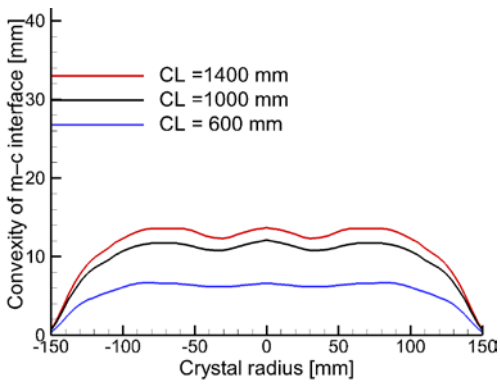

Fig. 1 m-c interface shapes during crystal pulling.

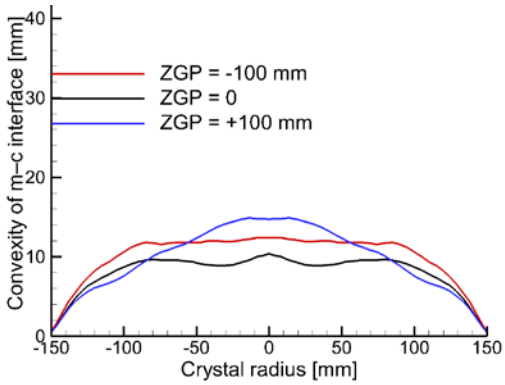

Fig. 2 m-c interface shapes for different CMFs.

[1] Xin Liu et al., Journal of Crystal Growth, 2020, 532, 125405.

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