Czochralski 単結晶成長法を用いた気固相界面での相互作用による SiC、SiO_2 凝結過程の数値解析

Numerical analysis of SiC and SiO_2 deposition processes by gas-solid interaction in Czochralski silicon crystal growth

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Czochralski (CZ) crystal growth of single crystalline silicon (Si) is invariably accompanied by transport of species such as carbon (C), oxygen (O), and related products from chemical reactions in the high temperature range. Complex reactions among species and furnace elements result in the formation of different deposition layers. Depositions of Si, SiO, SiO_2 and SiC in CZ-Si system are undesirable owing to their negative effects on the crystal growth process, such as poly Si growth, degradation of heater and obstruction of gas flow. Therefore, mechanisms of the gas-solid interaction and the deposition process are critical for the active control of impurity transport in CZ-Si crystal growth.

To investigate the dynamic deposition processes, transient global simulations of heat and mass transport were conducted for melting process of CZ-Si crystal growth. The deposition processes of SiO_2 and SiC are shown schematically in Fig. 1. An extended chemical model, which accounts for the gas-solid interactions, was developed to predict the deposition rate of SiO_2 and SiC on furnace elements. The thickness of deposition layers could also be estimated by the integration of the deposition rate for the duration of the melting process. Thicknesses of SiC deposition layers along the inner and outer surfaces of the heater are present in Fig.2, as well as the temperature profiles. The SiC deposition on the inner side of the heater is remarkable due to the SiO absorption by graphite. The removal of SiO must be reinforced to reduce the depositions of SiO_2 and SiC by the enhancement of gas flow in CZ-Si crystal growth.

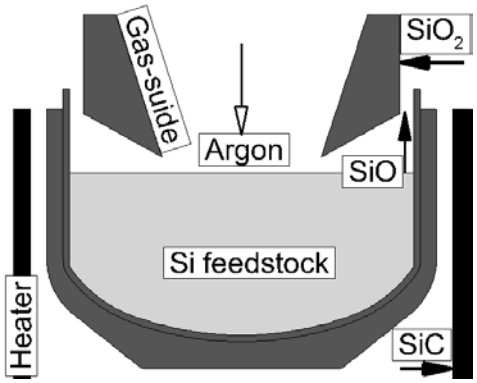

Fig. 1 Depositions of SiO_2 and SiC in hot zone

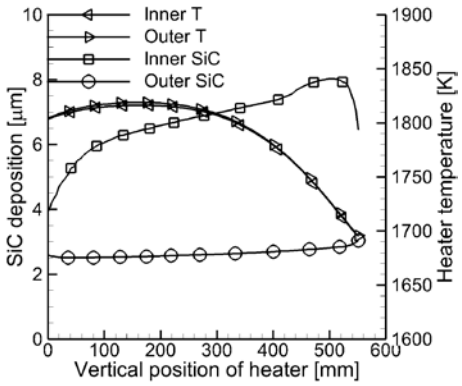

Fig. 2 Deposition layer of SiC on the heater

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