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異なるガス流れ解法を用いた CZ-Si 結晶成長における アルゴンガス流れおよび不純物輸送の予測

Prediction of Argon Flow and Impurity Transport in a CZ-Si Crystal Growth with Different Gas Flow Solvers

九大応力研

○劉 鑫，高 冰，中野 智，柿本 浩一

RIAM, Kyushu Univ.

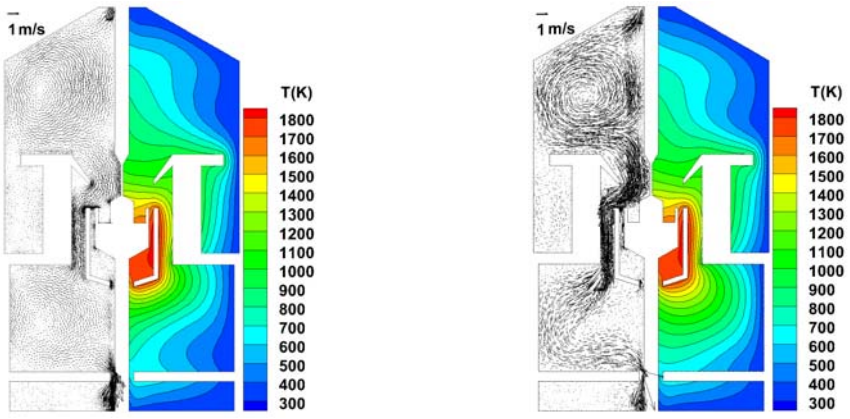
○Xin Liu, Bing Gao, Satoshi Nakano and Koichi Kakimoto

E-mail: liuxin@riam.kyushu-u.ac.jp

The Czochralski (CZ) method is the dominant technique to produce bulk single crystals of a wide range of electronic and photovoltaic silicon. Global simulation, including argon flow and melt convection, must be carried out to predict the impurity transport in the furnace. Therefore, a precise computation of the compressible argon flow is very important to investigate the relevant heat and mass transport phenomena in CZ-Si crystal growth.

It is well-known the argon flow involves low velocity (low Mach number) but intensive density variations due to the large temperature differences within the CZ-Si furnace. In the present study, the anelastic approximation and the acoustically filtered equations were introduced respectively to solve the viscous, low-Mach compressible argon gas flow. Global simulations were implemented with different gas flow solvers. Their capabilities to reproduce the compression effect of gas flow were evaluated.

Fig. 1 shows the comparison of flow fields temperature distributions predicted by different flow solvers. They yielded similar flow structures and isotherm distributions. However, the acoustically filtered equations predicted much intensive compressible effect near the regions with large density variations. Particularly in the inlet affected region, the narrow gap between the heater and heat shield, it can be found that the density variations result in the strong velocity magnitude variations. The coupled impurity distributions in the CZ-Si growth were also predicted by the developed programs.



(a) Anelastic (conventional)　　(b) Acoustically filtered (newly developed)

Fig. 1 Flow fields and temperature distributions predicted by different flow solvers