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# Effect of Hot zone Design on Heat and Fluid Flows in Kyropoulos 6-inch Single Crystal Sapphire Growth

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As the demand for production cost reduction and high efficiency in light emitting diode has been increased, there has been interest in growing sapphire crystals of large size and high quality. In many ways of sapphire crystal growth, Kyropoulos method is one of the most widely used processes in the industry for growing commercially available sapphire ingot.

In this work, we investigated the effect of hot zone design such as shield and insulator by the numerical simulation to improve the ingot quality of 6-inch pure sapphire grown by Kyropoulos method. The global heat transfer in the whole system, convection of sapphire melt, temperature distribution in sapphire ingot grower, melt/crystal interface shape and thermal stress distributions were simulated. The computations had been performed by the CGSim program package. Kyropoulos crystal growth had been numerically calculated by considering a 2-dimentional axisymmetric.

Figure 1 shows the schematic hot zone structure of the computational domain of the Kyropoulos furnace. Figure 2 shows the heater power and interface deflection (a), temperature gradient (b), interface shape (c), and v/G (d). It was shown that the increase in the number of zirconia insulator in sapphire ingot grower made smaller heater power consumption and larger distribution of temperature gradient along the interface of solid/liquid. Figure 3 shows the flow pattern (left) and temperature gradient (right) of the region of liquid sapphire. We confirmed that the hot zone design influences the quality of sapphire crystals because of determining the distributions of both radial and vertical temperature gradients in the whole system and the thermal stress in the sapphire crystals.

In our presentation, we review detailed features of melt convection for crystal growth stages by taking account of several structures of hot zone design.

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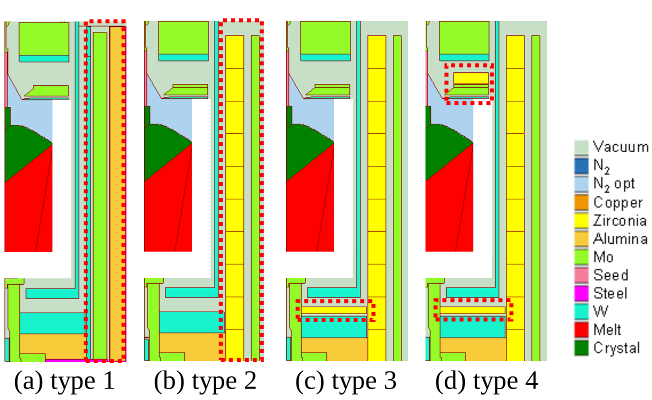


Fig. 1. Schematic hot zone structure of the computational domain for Kyropoulos furnace.

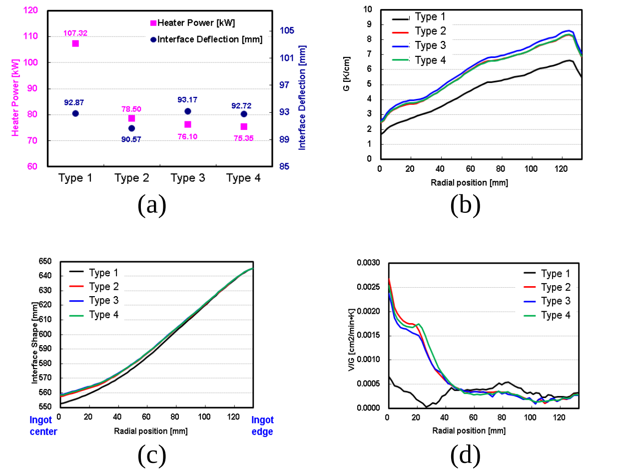


Fig. 2. Simulation results of several structures of hot zone design; (a) comparison of heater power consumption and interface deflection, (b) temperature gradient along the interface, (c) interface shape between solid and melt, and (d) ratio of V (crystal pulling rate) to G (temperature gradient at the interface between the silicon solid and melt) during crystal growth.

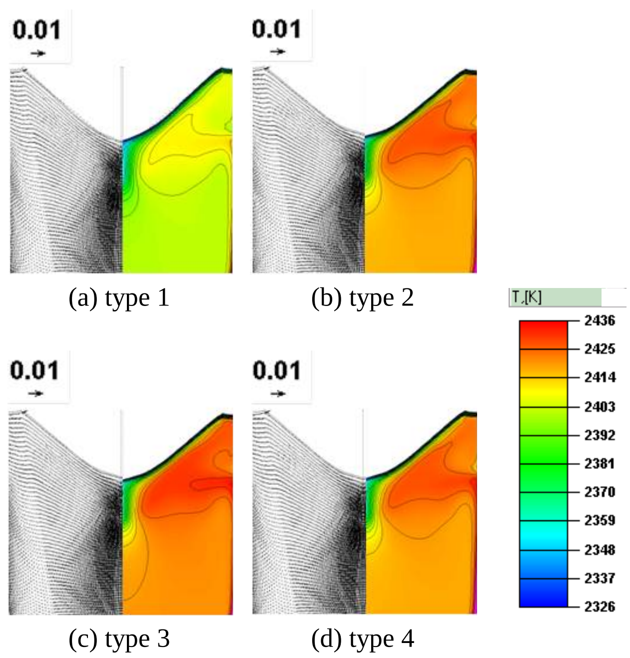


Fig. 3. Flow pattern (left) and temperature distribution (right) of liquid sapphire; (a) type 1, (b) type 2, (c) type 3, and (d) type 4.

**Reference**

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