Evolution of sapphire melt convection at the transition to large scale Ky technology.

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Sapphire wafers of large diameter make LED manufacturing process significantly more efficient. Leading LED chip manufacturers have already moved from 2-inch to 4-inch substrates, and coming transition to 8-inch wafers was announced. However, the wafer thickness may increase significantly with diameter due to requirements of MOCVD and processing. Hence, more sapphire material is needed to meet this increased demand.

Economical conditions force the industry to produce larger sapphire boules or plates with subsequent scaling up of manufacturing equipment. Kyropoulos growth technique is well developed for sapphire charges up to 90 kg in a single crucible. Further increase in sapphire charge weight and crucible size generates additional difficulties during seeding stage and reduces the range of parameters within which it is possible to grow high quality crystals with high yields.

Using 3D computer simulations [1] and experimental observations, we have studied sapphire melt convection in crucibles containing 1, 30, and 65 kg sapphire charge. Quite different flow patterns were observed on the melt free surface for different charges. It was found out that there is a star-like flow structure in small scale crucibles, being indicative of optimality condition for stable and rapid seeding. For 65 kg charge, the flow structure changes to chaotic if the hot zone design suitable for 30 kg charge is simply scaled up to a larger furnace. 3D computer simulation has been applied for optimization of the furnace design and stabilization melt flow during seeding stage in 65 kg sapphire growth furnace. Modified conditions helped to reduce significantly the seeding time.