Effect of power history on the shape and the thermal stress of a large sapphire crystal during the Kyropoulos process

Tran Phu Nguyen, Hsiao-Tsun Chuang, Jyh-Chen Chen, Chieh Hu

PII: S0022-0248(17)30728-5
DOI: https://doi.org/10.1016/j.jcrysgro.2017.12.027
Reference: CRYS 24417

To appear in: *Journal of Crystal Growth*

Please cite this article as: T.P. Nguyen, H-T. Chuang, J-C. Chen, C. Hu, Effect of power history on the shape and the thermal stress of a large sapphire crystal during the Kyropoulos process, *Journal of Crystal Growth* (2017), doi: https://doi.org/10.1016/j.jcrysgro.2017.12.027

Effect of power history on the shape and the thermal stress of a large sapphire crystal during the Kyropoulos process

Tran Phu Nguyen[1], *Hsiao-Tsun Chuang*[1], *Jyh-Chen Chen*[1,*], *Chieh Hu*[1]

[1]*National Central University, Jhongli (Taiwan)*
**jcchen@ncu.edu.tw*

Highlights

- Numerical simulation of a 90 kg sapphire crystal during the Kyropoulos process.
- Effect of the power history on the shape of the sapphire crystal and the thermal stress.
- Thermal stress distributions in the crystal for all growth stages.
- Optimal power history which will produce the lowest thermal stress inside the crystal.

Abstract

In this study, the effect of the power history on the shape of a sapphire crystal and the thermal stress during the Kyropoulos process are numerically investigated. The simulation results show that the thermal stress is strongly dependent on the power history. The thermal stress distributions in the crystal for all growth stages produced with different power histories are also studied. The results show that high von Mises stress regions are found close to the seed of the crystal, the highly curved crystal surface and the crystal-melt interface. The maximum thermal stress, which occurs at the crystal-melt interface, increases significantly in value as the crystal expands at the crown. After this, there is reduction in the maximum thermal stress as the crystal lengthens. There is a remarkable enhancement in the maximum von Mises stress when the crystal-melt interface is close to the bottom of the crucible. There are two obvious peaks in the maximum Von Mises stress, at the end of the crown stage and in the final stage, when cracking defects can form. To alleviate this problem, different power histories are considered in order to optimize the process to produce the lowest thermal stress in the crystal. The optimal power history is found to produce a significant reduction in the thermal stress in the crown stage.

Keywords: A1. Computer simulation, A1. Heat transfer, A1. Stresses, A2. Kyropoulos method, A2. Single crystal growth, B1. Sapphire.