ELSEVIER

Journal of Crystal Growth 149 (1995) 147–152

JOURNAL OF CRYSTAL GROWTH

Letter to the Editors

Unsteady thermoelastic analysis of dislocation generation during Czochralski crystal growth

Chi-Chuan Hwang [a,*], Senpuu Lin [b]

[a] *Department of Mechanical Engineering, Chung Yuan University, Chung-Li, Taiwan 32023, ROC*
[b] *Department of Mechanical Engineering, Lien-Ho College of Technology and Commerce, Miao-Li, Taiwan 36012, ROC*

Received 20 October 1994; manuscript received in final form 19 December 1994

Abstract

The perturbation method is implemented to solve the unsteady temperature distributions and thermoelastic dislocation generation with planar/curved interface shape during Czochralski crystal growth. To show the effects of the unsteady terms, comparison is made between the present unsteady-state (US) results and previous quasi-steady-state (QSS) and steady-state (SS) results. It is found that in the QSS model the quantities of the temperature distributions, thermal stresses and dislocation density of crystal, are the largest, those in the SS model are smaller, and those in the US model are the smallest. Furthermore, the model difference between any two of them will increase with increasing the Peclet number. Also, for a small value of the ambient Biot number, the model difference of the dislocation density increases with increasing ambient Biot number. However, if the ambient Biot number is large enough, increasing the ambient Biot number has no effect on the model difference.

In recent years, there has been a rapidly growing interest in research on the thermal stress produced in a single crystal by temperature variations during Czochralski growth [1–24]. Most of these early works have neglected the time-dependent term in the governing heat conduction equation. They undertook a quasi-steady-state (QSS) or steady-state (SS) thermoelastic analysis. However, in a more precise investigation, the unsteady term should not be neglected. It is believed that this term will provide some effect on the generation of dislocations. There are a number of approaches one can take to find a solution of the time-dependent problem. Crowley [21], Derby et al. [22], Kopetsh [23] and Venerus [24] have used coordinate transformations with the finite difference (element) methods to obtain numerical solutions to the unsteady problem during Czochralski growth. In these solutions, small time step and spatial step sizes were necessary to ensure a stable and converged solution. In industries, it costs too much time to evaluate each iteration using these numerical methods. Application of perturbation methods, which will reduce the computation load, in unsteady heat transfer problems deserves special attention. Aziz and Lunardini [25] reviewed perturbation techniques in phase change heat transfer. In this article, the perturbation technique is extended to obtain the temperature distributions in the crystal by solving the unsteady-state (US) heat conduction equation

* Corresponding author.

0022-0248/95/$09.50 © 1995 Elsevier Science B.V. All rights reserved
SSDI 0022-0248(95)00002-X