

Author's Accepted Manuscript

A fundamental limitation on growth rates in the traveling heater method

Jeffrey H. Peterson, Andrew Yeckel, Jeffrey J. Derby



www.elsevier.com/locate/jcrysgr

PII: S0022-0248(15)00631-4
DOI: <http://dx.doi.org/10.1016/j.jcrysgr.2015.10.025>
Reference: CRY23036

To appear in: *Journal of Crystal Growth*

Received date: 1 October 2015
Revised date: 20 October 2015
Accepted date: 23 October 2015

Cite this article as: Jeffrey H. Peterson, Andrew Yeckel and Jeffrey J. Derby, A fundamental limitation on growth rates in the traveling heater method, *Journal of Crystal Growth*, <http://dx.doi.org/10.1016/j.jcrysgr.2015.10.025>

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting galley proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

A fundamental limitation on growth rates in the traveling heater method

Jeffrey H. Peterson, Andrew Yeckel, Jeffrey J. Derby*

Department of Chemical Engineering and Materials Science, University of Minnesota, 151 Amundson Hall, 421 Washington Avenue SE, Minneapolis, MN 55455-0132, USA

Abstract

A comprehensive mathematical model of the traveling heater method is applied to understand interactions of flow, segregation, and stability for the crystal growth by the traveling heater method. We demonstrate that the formation of a secondary, counter-rotating vortex near the growth interface limits the transport of segregated solvent, leading to large concentration gradients and supercooling of the liquid near the interface. The secondary vortex arises from the same mechanism responsible for the formation of lee waves in atmospheric flows, and its spatial form scales with the Brunt–Väisälä frequency. Significantly, this supercooled layer of liquid arises from the lateral transport of solute, which is predominantly affected by the secondary flow vortex, rather than the axial diffusion of solute, as assumed in the classical derivation of constitutional supercooling by Mullins and Sekerka. Thus, supercooling in a model cadmium zinc telluride system occurs at growth rates of order 1 mm/day, nearly an order of magnitude smaller than expected from classical arguments. Paradoxically, the traditional strategy to alleviate constitutional supercooling during crystal growth, namely increasing the temperature gradient at the interface, is expected to strengthen the lee-wave vortex and accentuate the onset of instability. Other approaches will be needed to overcome growth limits in the traveling heater method.

Keywords: A1. Computer simulation, A1. Convection, A1. Mass transfer, Heat transfer, A2. Traveling heater method growth, A2. Traveling solvent zone growth, B2. Semiconducting II-VI materials

*Corresponding author. E-mail address: derby@umn.edu (J.J. Derby).

Download English Version:

<https://daneshyari.com/en/article/5489885>

Download Persian Version:

<https://daneshyari.com/article/5489885>

[Daneshyari.com](https://daneshyari.com)