



Three-dimensional phase-field simulations of the effect of convection on free dendritic growth

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Abstract

Three-dimensional free dendritic growth of a pure material into an undercooled melt in the presence of fluid flow is investigated numerically using the phase-field method. Such computations are made possible by solving the Navier–Stokes equations for the flow and the energy equation for the heat transport on a grid that is twice as coarse as the grid for the phase-field equation. The effect of the flow on the upstream growing dendrite tip velocity and radius of curvature is investigated as a function of the imposed flow velocity, undercooling, crystalline anisotropy, and Prandtl number. The results are compared to available theories of dendritic growth with and without convection. The predicted growth Péclet numbers as a function of the flow Péclet number are in reasonable agreement with the theoretical predictions. The dendrite tip selection parameter is essentially independent of the flow velocity within the range studied, which is also in accordance with theory. The three-dimensional dendrite tip shape is found to be well fitted by the same universal scaling relation as without flow.

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1. Introduction

Dendritic solidification of crystalline materials is a complex pattern formation process that is

governed by the combined action of heat transport (for pure materials) and surface tension. Understanding dendritic growth is important, for example, for predicting microstructures in solidified metals. In the absence of melt flow, a theory is available to predict the steady-state velocity, V , and radius of curvature, R_p , of the tip of a dendritic needle crystal of a pure substance

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Convection Effects In Three Dimensional Dendritic Growth

Wenbin Ji

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Table of Contents Convection Effects In Three Dimensional Dendritic Growth

1. Understanding the eBook Convection Effects In Three Dimensional Dendritic Growth
 - The Rise of Digital Reading Convection Effects In Three Dimensional Dendritic Growth
 - Advantages of eBooks Over Traditional Books
2. Identifying Convection Effects In Three Dimensional Dendritic Growth
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Convection Effects In Three Dimensional Dendritic Growth
 - User-Friendly Interface
4. Exploring eBook Recommendations from Convection Effects In Three Dimensional Dendritic Growth

- Personalized Recommendations
- Convection Effects In Three Dimensional Dendritic Growth User Reviews and Ratings
- Convection Effects In Three Dimensional Dendritic Growth and Bestseller Lists
- 5. Accessing Convection Effects In Three Dimensional Dendritic Growth Free and Paid eBooks
 - Convection Effects In Three Dimensional Dendritic Growth Public Domain eBooks
 - Convection Effects In Three Dimensional Dendritic Growth eBook Subscription Services
 - Convection Effects In Three Dimensional Dendritic Growth Budget-Friendly Options
- 6. Navigating Convection Effects In Three Dimensional Dendritic Growth eBook Formats
 - ePub, PDF, MOBI, and More
 - Convection Effects In Three Dimensional Dendritic Growth Compatibility with Devices
 - Convection Effects In Three Dimensional Dendritic Growth Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Convection Effects In Three Dimensional Dendritic Growth
 - Highlighting and Note-Taking Convection Effects In Three Dimensional Dendritic Growth
 - Interactive Elements Convection Effects In Three Dimensional Dendritic Growth
- 8. Staying Engaged with Convection Effects In Three Dimensional Dendritic Growth
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Convection Effects In Three Dimensional Dendritic Growth
- 9. Balancing eBooks and Physical Books Convection Effects In Three Dimensional Dendritic Growth
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Convection Effects In Three Dimensional Dendritic Growth
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Convection Effects In Three Dimensional Dendritic Growth
 - Setting Reading Goals Convection Effects In Three Dimensional Dendritic Growth
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Convection Effects In Three Dimensional Dendritic Growth

- Fact-Checking eBook Content of Convection Effects In Three Dimensional Dendritic Growth
- Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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