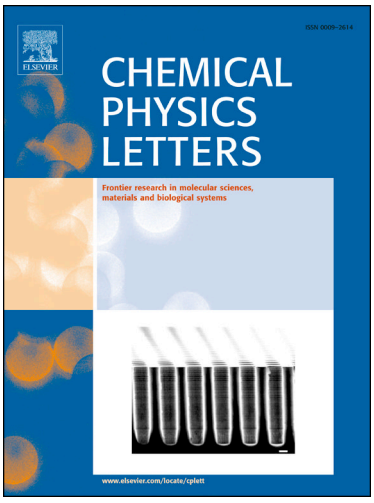

Research paper

Heterogeneous nucleation and dendritic growth within undercooled liquid niobium under electrostatic levitation condition

S.J. Yang, L. Hu, L. Wang, B. Wei

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Heterogeneous nucleation and dendritic growth within undercooled liquid niobium under electrostatic levitation condition

S. J. Yang, L. Hu, L. Wang, B. Wei[1]

Department of Applied Physics, Northwestern Polytechnical University, Xi'an 710072, China

Abstract: The physical mechanisms of crystal nucleation and dendritic growth within undercooled niobium were systematically studied by electrostatic levitation and molecular dynamics methods. The maximum undercooling was achieved as 454 K ($0.16T_m$), while the hypercooling limit was determined as 706 K ($0.26T_m$). The undercooling probability displayed Poisson distribution and indicated the occurrence of heterogeneous nucleation. The calculated critical nucleus size reduced rapidly with undercooling and the solid-liquid interface energy was deduced to be 0.367 J m^{-2}. In addition, the dendritic growth velocity of pure niobium exhibited a power relation versus undercooling, and reached 41 m s^{-1} at the maximum undercooling.

Keywords: Crystal nucleation; Dendritic growth; Liquid undercooling; Refractory metal

1. Introduction

Crystal nucleation and dendritic growth, which are the most fundamental stages of solidification process, have aroused great research interests due to their important roles on controlling the phase constitutions and structural morphologies of metallic materials. [1-5] Thermodynamically, nucleation and subsequent dendritic growth from metallic melt both need undercooling as the driving force. [6] With the undercooling increase, the Gibbs free energy of the undercooled melt remarkably departs away from that in equilibrium state. Therefore, the nucleation and dendrite growth kinetics must display different physical laws with the change of undercooling status.

Since the undercooling state is very sensitive to the external heterogeneous sites, i.e., container and oxidation

[1] Corresponding author
E-mail address: bwei@nwpu.edu.cn (B. Wei)