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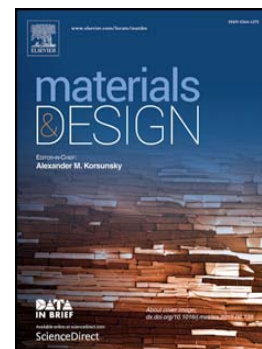
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T.F. Flint, C. Panwisawas, Y. Sovani, M.C. Smith, H.C. Basoalto

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Prediction of Grain Structure Evolution During Rapid Solidification of High Energy Density Beam Induced Re-Melting[☆]

T.F. Flint^{a,*}, C. Panwisawas^{b,*}, Y. Sovani^b, M.C. Smith^a, H.C. Basoalto^b,

^a*Dalton Nuclear Institute, The University of Manchester, Manchester M13 9PL, UK*

^b*School of Metallurgy and Materials, The University of Birmingham, Edgbaston, Birmingham B15 2TT, UK*

Abstract

Grain boundary migration in the presence of concentrated sources of heat is a complex process that has a considerable impact on resultant material properties. A phase field model is presented incorporating thermal gradient and curvature driving force terms to predict how a poly-crystalline network evolves due to the application of such heat sources, as grain boundaries migrate due to local boundary curvature and time varying thermal gradients. Various thermal scenarios are investigated, in both two and three dimensions. These scenarios include both partial and full penetration laser induced melting, the application of a linearly varying time-independent thermal field, and successive melting events where regions experience multiple melting and solidification cycles. Comparisons are made between the microstructures predicted by the proposed phase field method, during the various thermal scenarios, that agree with commonly observed phenomena. Particularly interesting is the ability to explain the differences in grain morphology between the full penetration and partial penetration welds using the phase field model and associated driving force magnitudes between the two scenarios. The model predicts the restoration of grain boundary networks in regions experiencing multiple melting events, and explains the differences in grain morphology due to the local curvature and thermal gradient effects.

Keywords: Phase Field, Thermal Field, Re-Melting, Thermal Gradient, Grain Boundary Migration

1. Introduction

Understanding solid-to-liquid transitions in advanced processes such as additive manufacturing and welding is fundamental in establishing causal relation-

*Corresponding author

Email address: Thomas.Flint@manchester.ac.uk (T.F. Flint)

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