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Characterization of the microstructure transition during the solidification of metal alloys under the influence of external forces

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ABSTRACT

During the solidification of metal alloys, microstructure always changes in response to the applied external forces. To fully understand such response of the microstructure is crucial for designing or adjusting existing processing techniques. To achieve this, a 3-D phase field model was developed and employed to simulate the microstructure transition during solidification of metal alloys. An algorithm, namely Para-AMR, comprising of adaptive mesh refinement (AMR) and parallel (Para-) computing capabilities was developed to solve the phase field equations, and numerical tests showed that the computing efficiency could be increased by ~3 orders of magnitude. Synchrotron X-ray image techniques, including radiography and tomography, were also applied in this study to (1) reveal the full physics of the solidification phenomena in real space and time scales and (2) to fully testify the validity of the phase field modeling results. Accordingly, important solidification behaviors, including dendrite growth, fragmentation (under the influence from electromagnetic forces and ultrasounds), and coarsening, were studied and compared with either experiment results or existing theories.

KEYWORDS: phase field, synchrotron X-ray, solidification, dendrite, external force