

2D and 3D Phase-Field Simulations of Competitive Dendrite Growth During Directional Solidification of Binary Alloy

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Many material microstructures are formed through a collective competitive growth of multiple dendrites in casting [1]. In order to numerically evaluate such competitive growth process of multiple dendrites, we need large computational cost resulting from wide computational domain. Therefore, in our previous studies [2], we enabled very-large-scale phase-field computation with about $4,000 \times 4,000 \times 4,000$ meshes and four million time steps using a graphics processing unit (GPU) the TSUBAME2.0 super computer at Tokyo Institute of Technology.

In this study, 2D and 3D phase-field simulations of competitive dendrite growth during directional solidification of Al-Cu binary alloy are performed by parallel computing with the GPU and the CUDA programming environment. Here, we investigate an unexpected phenomenon [3-6], in which an unfavourably oriented dendrite can stop the growth of a favourably oriented dendrite, by 2D simulations in detail and the deference of the phenomenon in 2D and 3D problem. A quantitative phase-field model for dilute ally solidification [7] is used here.

Figure 1 shows computational examples of dendritic growth during directional solidification of Al-3wt%Cu alloy. The computational domain is $1,024 \mu\text{m} \times 64 \mu\text{m} \times 768 \mu\text{m}$ ($2,048 \times 128 \times 1536$ meshes). A constant temperature gradient is set to z -direction. Initially, a small nucleus is placed on the lattice point of $(0, 128, 0)$ and it grows to x -direction with wetting the bottom surface. Then, some dendrites grow to z -direction with competition. Growth processes at 550000 steps are shown in Fig. 1, where the preferred growth directions are set to (a) $\theta = 0^\circ$ and (b) $\theta = 30^\circ$, respectively. Although these computations are performed for single crystal, the presentation will be done for bicrystal and polycrystal with different preferred growth directions.

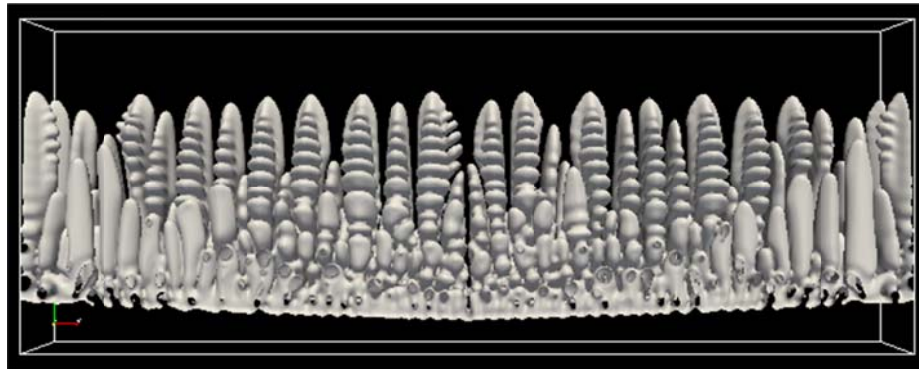
(a) $\theta = 0^\circ$ (b) $\theta = 30^\circ$

Fig. 1 Dendritic growth during directional solidification of Al-3wt%Cu alloy (550,000 steps).

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