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静電浮遊実験における Ti6Al4V の結晶粒微細化シミュレーション

Grain Refinement Simulation of Ti6Al4V in Electrostatic Levitation Experiments

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1. Introduction

To clarify the grain refinement mechanism of Ti6Al4V alloy with heterogeneous nucleation site particles TiC, a space mission named *Hetero-3D* was conducted using the electrostatic levitation furnace in the International Space Station. However, TiC particles added in Ti6Al4V dissolved in a previous study of melting experiments in the electrostatic levitation (ESL) furnace[1)]. It is unclear how much TiC remains compared to the amount of TiC addition. The objective of this study was to clarify the nucleus setting condition (seed density[2)]) in the phase-field simulation so as to simulate the numbers of grains formed in the ESL experiments.

2. Experimental Procedures

The spherical samples of Ti6Al4V with 5 mass% TiC[1)] were melted and solidified by lasers in the ESL furnace, and the temperature histories were obtained. After the experiments, each sample was polished and the number of prior-β grains in the region of 750 × 750 μm² at the center of the cross-section was obtained by using SEM-EBSD. In addition, the integral value of heating[1)] was calculated from the temperature history in each sample. The integral value was maintained between 5.5×10^7 and 7.5×10^7 K^2s in the ESL experiment.

On the other hand, grain refinement simulations were performed by phase-field software MICRESS[3)] using the seed density model based on the particle size distribution and mass fraction of the as-received TiC. The cooling rate was set to 71 K/s according to the calculation result of heat transfer, and the simulation region was the same as the SEM-EBSD analysis. The physical properties were referenced from a previous study[4)].

3. Results

The number of prior-β grains obtained by the ESL experiments and simulations are shown in **Fig. 1**. The number of prior-β grains in the two ESL samples were 5 and 9, which are consistent with the simulation results when seed density conditions correspond to 0.65 - 1.5 mass%.

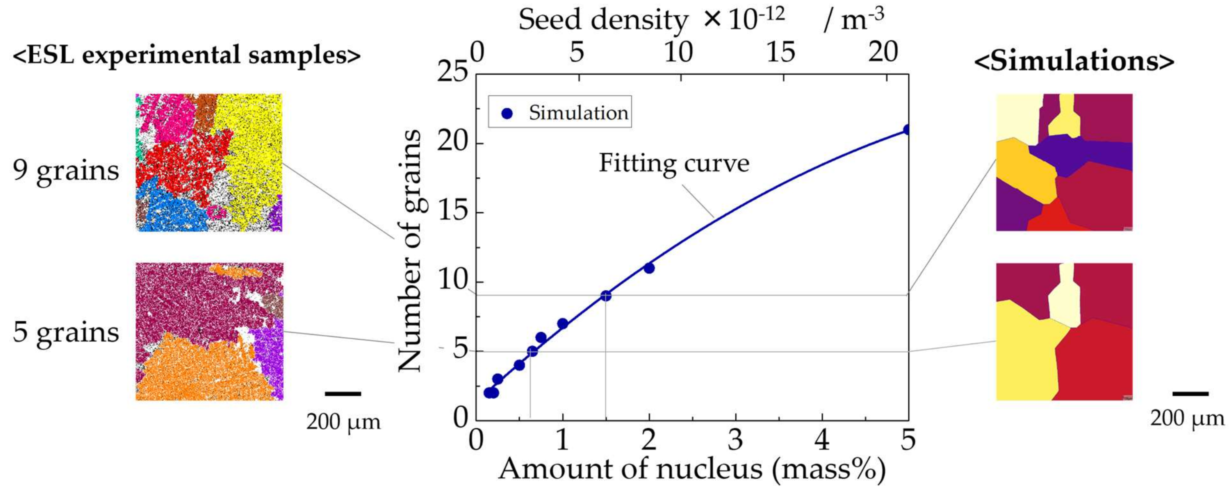

Figure 1. The number of prior-β grains obtained by ESL experiments and simulations.

4. Discussion

The relationship between the amount of nucleus and the number of grains was approximated in a curve (**Fig. 1**). In a simulation, nucleus grains are generated from within the target region, while the results of SEM-EBSD analyses of ESL samples include grains nucleated outside the target region. Therefore, even though the number of prior-β grains in the region is the same as simulation, the actual number of nucleus may be smaller than that in the simulation. This is inferred from the presence of small grains in the ESL experimental results (**Fig. 1**).

5. Conclusions

The numbers of grains obtained from the simulations were compared with the numbers of prior-β grains obtained from the ESL experimental results. As the results, the same numbers of prior-β grains are formed in both ESL experiments and simulations when seed density corresponds to 0.65 - 1.5 mass%.

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