Paper ID: 88738
interactive
student

IAF MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Microgravity Sciences on board of Space stations (6)

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GRAIN ANALYSIS METHOD OF METAL MATERIAL FOR AM LEVITATED AND SOLIDIFIED IN ISS

Abstract

1 Introduction

A high-strength material for AM was developed by incorporating TiC into Ti-6Al-4V to achieve improved mechanical properties. To elucidate the strengthening mechanism attributed to TiC, melt and solidification experiment was conducted in the electrostatic levitation furnace in the ISS (ISS-ELF), where extraneous factors could be eliminated. This study proposes an efficient method to estimate active TiC from the valuable sample.

2 Experimental Procedures

Ti-6Al-4V with 5 mass% of TiC was melted for about 20 s and solidified in the furnace, resulting in an approximately 2 mm diameter spherical sample. Mechanical polishing obtained cross sections, and an electron backscatter diffraction detector analyzed crystal orientation. Polishing and orientation analysis were repeated to obtain the cross-sectional grain count, N_{2D-exp}, at depths from the surface, $d = 40, 120, 200, 290$, and 350μm. For three dimensional Voronoi tessellation, point site data were outputted in cubic form ranging from 500, 1000 to 6000 points at 1000-point intervals. The converted number of grains to a sphere, $N_{3D-voro}$, was obtained. Cross sections were cut at depth, d, to obtain cross-sectional grain count, $N_{2D-voro}$.

3 Results and Discussion

The values of N_{2D-exp} at each depth were 7, 20, 48, 57, and 65, respectively. The amount of ε_{2D}, which represents the difference between N_{2D-exp} and $N_{2D-voro}$ at each depth section, increases with the difference from $N_{3D-voro} = 524$. The average ε_{2D} value was 5%. To verify the reliability of the results, the sample was polished further to $d = 1200\mu$m, revealing 96 grains in the cross section and an ε_{2D} value of only 8%. Based on the Voronoi model with $N_{3D-voro} = 524$, the sample was expected to have $N_{3D-exp} = 524 \pm 42$. According to previous research, added TiC particles of 81,000 remain 2200 after heating in 20 s. Therefore, the N_{3D-exp} result indicates that the active TiC is only about 25% of the remaining TiC.

4 Conclusions

Grain counts in the sample were obtained by examining cross sections up to a 16% depth and supplementing the unpolished area with a Voronoi model selected by minimal ε_{2D}. With only 16% loss, it was determined that remaining TiC particles of about only 25% in the entire sample act as active TiC. Applying this method to valuable ISS-ELF samples allows the estimation of TiC induced contribution to higher strength with minimal sample loss.