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Hetero-3D ミッションにおける TiC を添加した
Ti 合金試料の ISS-ELF による溶融凝固実験Melting and Solidification Experiments of Ti Alloy
Samples with TiC by ISS-ELF in *Hetero-3D* Mission

鈴木進補¹, 花田知優¹, 馬淵勇司¹, 青木祐和¹, 上田雄翔¹, 門井洸衛¹, 櫛舎祐太¹,
山田素子², 左口凌成², 米田香苗², 佐藤尚², 渡辺義見², 清宮優作³, 原田侑直³, 小澤俊平³,
碓井昶郎⁴, 谷本滉平⁴, 白鳥英⁴, 中野禪⁵, 曾根武彦⁶, 榎戸一典⁶, 渡邊勇基⁷,
織田裕久⁸, 小山千尋⁸, 池内留美子⁸, 下西里奈⁸, 石川毅彦⁸

Shinsuke SUZUKI¹, Chihiro HANADA¹, Yuji MABUCHI¹, Hirokazu AOKI¹, Yuto UEDA¹,
Koei KADOI¹, Yuta KUSHIYA¹, Motoko YAMADA², Ryosei SAGUCHI², Kanae YONEDA²,
Hisashi SATO², Yoshimi WATANABE², Yusaku SEIMIYA³, Yuma HARADA³, Shumpei OZAWA³,
Takuro USUI⁴, Kohei TANIMOTO⁴, Suguru SHIRATORI⁴, Shizuka NAKANO⁵,
Takehiko SONE⁶, Kazunori ENOKIDO⁶, Yuki WATANABE⁷, Hirohisa ODA⁸, Chihiro KOYAMA⁸,
Rumiko IKEUCHI⁸, Rina SHIMONISHI⁸, and Takehiko ISHIKAWA⁸

¹ 早稲田大学, Waseda University,

² 名古屋工業大学, Nagoya Institute of Technology,

³ 千葉工業大学, Chiba Institute of Technology,

⁴ 東京都市大学, Tokyo City University,

⁵ 株式会社 Henry Monitor, Henry Monitor Inc.,

⁶ 有人宇宙システム株式会社, Japan Manned Space Systems Corporation (JAMSS),

⁷ 株式会社エイ・イー・エス, Advanced Engineering Services (AES),

⁸ 宇宙航空研究開発機構, Japan Aerospace Exploration Agency (JAXA)

1. Introduction

The orbital experiments of the JAXA's science experimental theme "Heterogeneous solidification behavior of powder metals for 3D printer" (Abbreviation: *Hetero-3D*, PI: S. Suzuki, Waseda University) were carried out with the electrostatic levitation furnace in the International Space Station (ISS-ELF) as planned in 2023. The objective of this study is to investigate the effects of heterogeneous nucleation site particles on solidification behavior of metals by microgravity space experiments, which are ideal methods to exclude the effects of contamination from the container, evaporation and convection¹⁾. The heterogeneous nucleation site particles are added in metallic powder to refine crystal grains in 3D printing of metals. The obtained results are applied to improve the physical properties of the built products. This presentation introduces the overview and current status of the *Hetero-3D mission*.

2. Mission Progress and Future Plans

The pure Ti and Ti6Al4V samples with and without TiC were prepared and inspected²⁾. These samples, two Zr samples as oxygen getters, and a stainless-steel sample for scale-calibration were inserted in a cartridge for

the ISS-ELF on June 29, 2022.

The samples in the cartridge were set in a spacecraft Space-X Cargo Dragon. They were launched by a rocket Space-X Falcon 9 at the Kennedy Space Center as a commercial resupply service mission CRS-26 and arrived at ISS on November 27, 2022 (JST).

All of the planned orbital experiments were performed on eight days from April 14 to May 15, 2023(JST). Sixteen samples were levitated, melted and solidified as planned. Although only the first sample was lost during the levitation, the optimum levitation condition was found in this experiment. Since its spare sample was melted, necessary experiments were carried out. The samples was recovered to the earth by Space-X SpX-28 mission in June 30 2023, and will be observed and analyzed after recovery to our laboratory.

3. Experimental Procedure in ISS-ELF

In the beginning of every experimental day, the furnace was evacuated and filled with Ar gas. Then a Zr sample was melted in Ar atmosphere as an oxygen getter. A few runs of experiments were performed on every experimental day.

In every run, the sample position was controlled to be the center of the view by adjusting the voltage of the electrodes. The sample was heated by four laser beams and recorded by a high-speed camera. The temperature of the sample was measured by a pyrometer. When the temperature exceeded the melting temperature, the heating was stopped automatically. After cooling, the sample was recovered into the cartridge. The temperature and video data were acquired by telemetry.

4. Results

The obtained cooling curves showed that the samples with TiC tend to solidify with a smaller degree of undercooling than those without TiC, which implies the refinement effect by TiC. Crystal growth could be observed clearly in the video data obtained from the high-speed camera during the solidification of the samples, the grains of which are considered to be coarsened.

5. Summary

(1) The orbital experiments conducted in the *Hetero-3D* mission were largely successful, which meets the majority of predefined objectives and milestones.

(2) The telemetry data of temperature and video implied the refinement effect of crystal grains by TiC.

References

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