JASMAC Conference of the Japan Society of Microgravity Application

P22

分割型ノズルを用いたガスジェット法による白金融体の密度計測

Density Measurement of Liquid Platinum by Aerodynamic Levitation with Split Nozzle

高橋勇太 [1], 白鳥英 [2], 清宮優作 [1], 加藤蒼 [1], 小畠秀和 [3], 杉岡健一 [4], 石川毅彦 [5], 小澤俊平 [1]

Yuta TAKAHASHI[1], Suguru SIRATORI[2], Yusaku SEIMIYA[1], Sora KATO[1], Hidekazu KOBATAKE[3] Ken-ichi SUGIOKA[4], Takehiko ISHIKAWA[5], and Shumpei OZAWA[1]

[1] 千葉工業大学， Chiba Institute of Technology
[2] 東京都市大学，Tokyo City University
[3] 同志社大学， Doshisha University
[4] 富山県立大学， Toyama Prefectural University
[5] 宇宙航空研究開発機構，Japan Aerospace Exploration Agency (JAXA)

1. Introduction

Simulating a phase transition, such as crystallization and vitrification, requires highly accurate density, which is used as one of fundamental order parameters. However, with the conventional container method, it is difficult to measure accurate density of melt for high melting point materials, because the sample is usually contaminated from the supporting materials at elevated temperatures. To avoid any contamination during the density measurement of high-temperature melt, containerless techniques such as electromagnetic levitation (EML) and electrostatic levitation (ESL) have employed in recent years. In the EML technique, only conductive materials can be accommodated. Meanwhile, in the ESL technique, measuring samples with high vapor pressure poses challenges.

In this study, we attempt to use an aerodynamic levitator (ADL) equipped with a split nozzle to measure the density of high-temperature liquid platinum. While capturing the entire image of a levitated droplet is challenging using a standard aerodynamic levitator, splitting the nozzle after levitating the droplet enables us to observe it during its free fall.

2. Experimental procedure

Figure 1 shows a schematic diagram of the experimental setup of the ADL equipped with a split nozzle. A high-purity platinum cube with a mass of 38 mg was melted on a copper hearth by irradiating it with a semiconductor laser, forming an almost spherical shape with a diameter of 1.5 mm. This spherical sample was positioned on the ADL nozzle and levitated by a jet of Ar gas, injected from the bottom at a flow rate of approximately 400 mL/min. The levitated sample was heated and melted by irradiating it with a semiconductor laser beam from above. The temperature of the droplet was controlled by adjusting the laser power output with a monochromatic pyrometer. After the indicated temperature became constant, the ADL nozzle was horizontally split into two, allowing the droplet to fall freely. The entire image of the droplet during its free fall was captured from the side by a high-speed video (HSV) camera. To delineate the accurate contour of the sample, a semiconductor blue laser was used as a backlight, combined with a high-pass filter placed in front of the camera.

The contour of the free-falling droplet, immediately after the nozzle was split, was numerically fitted using Legendre polynomials. The volume of the droplet was calculated from the fitted data under the assumption that the droplet maintained rotational symmetry in alignment with the gravitational direction. The density of the droplet was calculated from the volume and the sample mass after experiment.

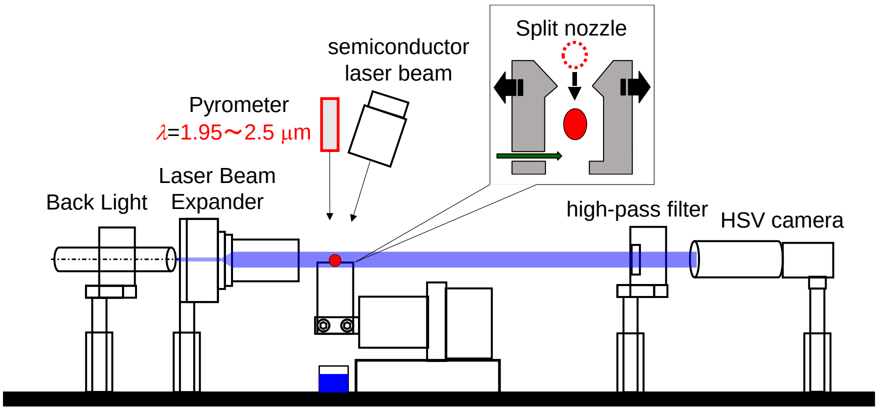

Figure. 1 schematic setup of ADR equipped with split nozzele

3. Results and Discussion

Figure 2 shows the density of liquid platinum measured in this study, along with some HSV images of the free-falling droplet corresponding to the measurement plots. For comparison, the literature data measured by Ishikawa et al.[1)] using ESL and Watanebe et al.[2)] using EML are also presented. The calculated density values for liquid platinum show significant scatter, lacking consistency in relation to temperature. This inconsistency can be attributed to two factors: (a) the unexpected formation of an unknown protuberance on the melt surface in certain measurements, and (b) the misalignment of the rotational symmetry axis with the gravitational direction. Due to these factors leading to an overestimation of the calculated volume, the resulting density value inevitably increases.

When obtaining a nearly spherical shape of the droplet image as shown in (c), the calculated density values align closely with the data reported by Ishikawa et al. and Watanebe et al. The unexpected appearance of the protuberance, even when using high-purity platinum, remains unexplained. Splitting the nozzle may causes a slight asymmetry in the gas pressure applied to the droplet, which in turn might affect its rotation axis. Further research is required to refine and improve the density measurements of high-temperature melts using ADL.

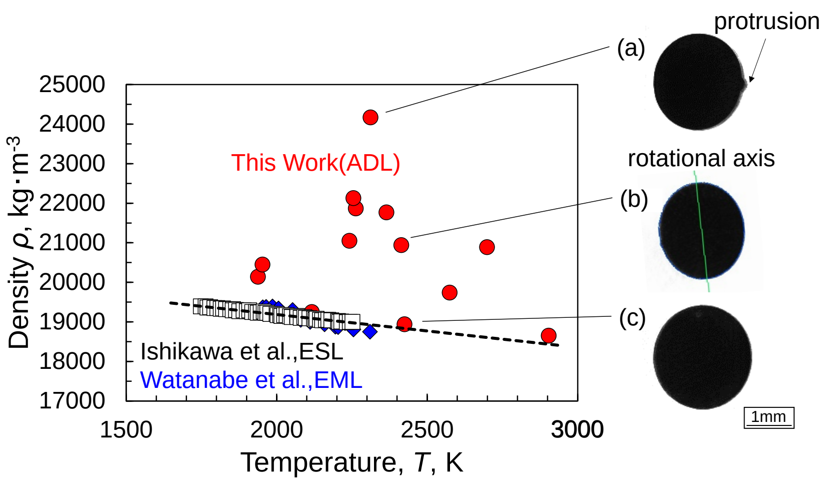

Figure.2 Density of liquid platinum results for different droplet shapes.

References

1) T. Ishikawa, P. F. Paradis, and N. Koike. Non-contact thermophysical property measurements of liquid and supercooled platinum. J. Appl. Phys, **45** (2006) 1719, DOI: https://doi.org/10.1143/JJAP.45.1719
2) M. Watanabe, M. Adachi, and M. Uchikoshi, H. Fukuyama.: Densities of Pt-X(X: Fe, Co, Ni and Cu) binary melts and thermodynamic correlations. Fluid Phase Equilib, **515** (2020) 1, DOI: https://doi.org/10.1016/j.fluid.2020.112596