JASMAC Conference of the Japan Society of Microgravity Application

OR1-3

分割型ノズルを用いたガスジェット浮遊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] Kenichi 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 36.5 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 contours of free-fall droplets with a flattening ratio of less than 1% were ellipse-fitted. 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.

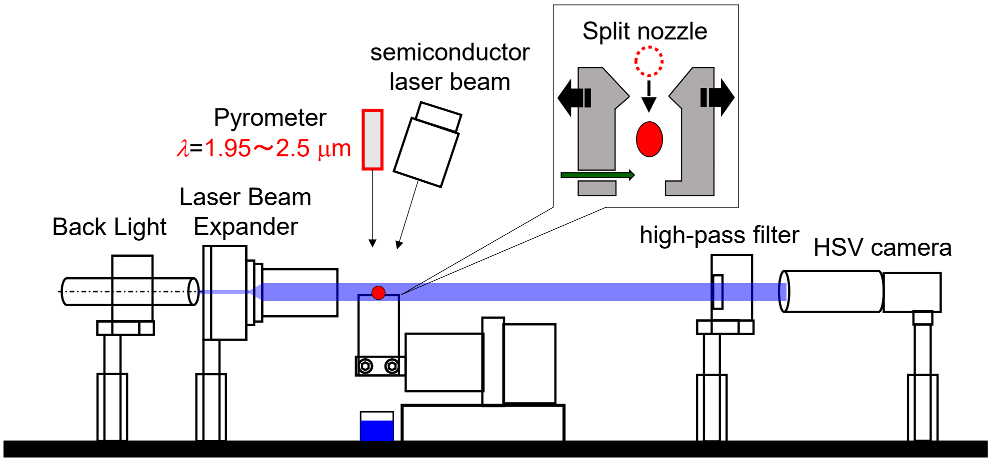

Figure. 1 schematic setup of ADL equipped with split nozzle

3. Results and Discussion

Figure 2 shows the density of liquid platinum measured in this study. For comparison, literature data measured by Ishikawa et al.[1] using ESL, Watanabe et al.[2] using EML, and Yifan Sun[3] using ADL are also presented. The calculated density values of the liquid platinum were lower than the literature data. The reason for this is considered to be the deformation caused by the rotation of the droplet. The floating droplets are rotated by the blowing gas. The centrifugal force caused by the rotational motion deformed the droplet and overestimated the droplet shape. This factor may have caused the low density of the droplets.

Further research is required to improve the density measurements of high-temperature melts using split nozzle.

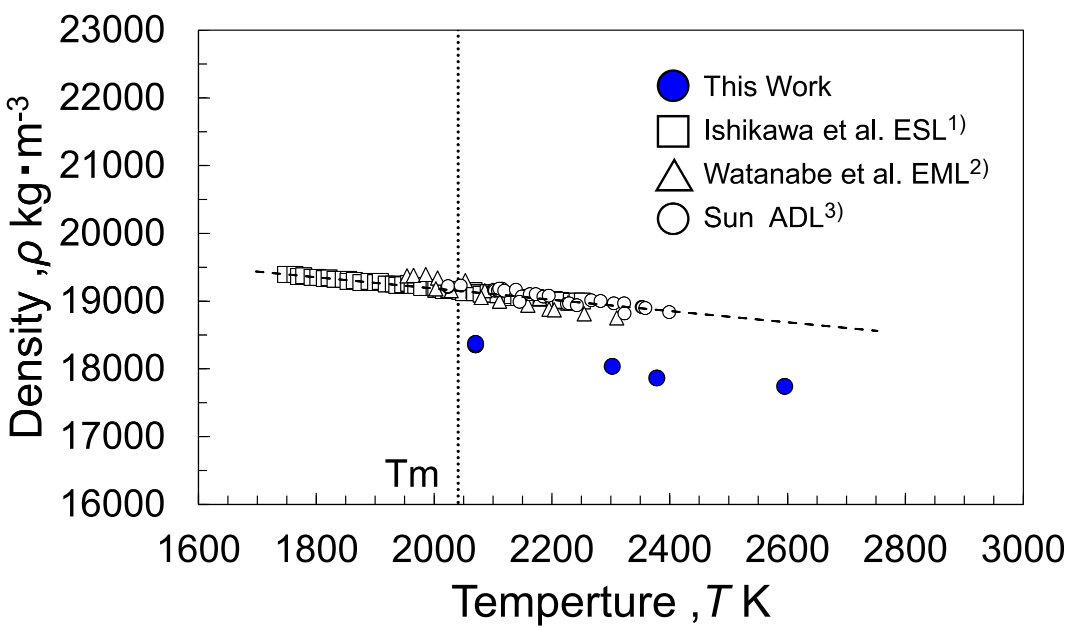

Figure.2 Density of liquid platinum.

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
3) Yifan. Sun. Development of Thermophysical Properties Measurement Methods for High-Temperature Liquids with Aerodynamic Levitation. 2022. Osaka University. Doctoral Dissertation. DOI: https://doi.org/10.18910/88066