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電磁浮遊炉を用いた表面張力測定における緩衝気体混合による酸素分圧制御の課題

Issues on Controlling Oxygen Partial Pressure Using Gas Phase Equilibrium for Surface Tension Measurements with an Electromagnetic Levitator

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1. Introduction

The oscillating droplet method using electromagnetic levitation (EML) is one of the most promising techniques for accurately and precisely measuring the surface tension of high-temperature molten metallic melts. This method avoids sample contamination by eliminating the need for a container. Additionally, atmospheric gas can be used to control the oxygen partial pressure (P_{O_2}) in the measurement atmosphere. However, when using gas phase equilibrium reactions such as CO-CO_2 and H_2-CO_2 to regulate P_{O_2}, it is crucial to ensure that the gas temperature matches that of the levitated droplet, as the small droplet itself is the only gas heating source.

This study aims to measure the surface tension of liquid copper under H_2-CO_2 atmosphere to investigate the effectiveness of gas-phase equilibrium in controlling P_{O_2} during EML measurements.

2. Experimental product

High-purity copper (99.99 at%) was electromagnetically levitated and melted under an Ar-He-H_2-CO_2 mixture gas flowing at 2L/min. The temperature of the droplet was controlled by adjusting the partial pressures of argon and helium gases, measured using a monochromatic pyrometer. The P_{O_2} at the inlet and outlet were monitored using a zirconia-type oxygen sensor operated at 1008 K. The oscillation behavior of the droplet was captured from above using a high-speed video (HSV) camera. The frequencies of the surface oscillations and the center of gravity were analyzed from HSV images. The surface tension of the liquid copper was calculated from these frequencies using the Rayleigh equation and Cummings and Blackburn calibration. The oxygen concentration of the quenched sample after the surface tension measurement was analyzed using an inert gas fusion oxygen analyzer.

3. Results and Discussion

Figure 1 shows the surface tension of liquid copper measured at 1488 K ± 15 K as a function of P_{O_2}, along with literature data for comparison. Although literature data indicate that an increase in P_{O_2} typically results

in a dramatic reduction in surface tension, the decrease observed in this study was relatively small. This imply that the Po_2 during the surface tension measurement may have been lower than expected, likely due to

insufficient heating of the atmospheric gas. Supporting this prediction, when assuming that the gas temperature was about 300 K lower than the sample temperature, the relationship between Po_2 and the oxygen concentration of the quenched sample aligns well regardless of the measurement.

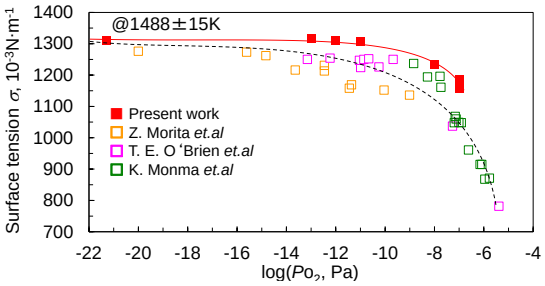

Fig 1 the surface tension of liquid copper measured

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