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ジルコニウム融体の表面張力解析を利用した酸素量推算：国際宇宙ステーションでの静電浮遊実験促進のために

Estimating Oxygen for Enhanced Utilization of the Electrostatic Levitation Furnace on the International Space Station *via* Surface Tension Analysis

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1. Introduction

The Electrostatic Levitation Furnace (ELF) aboard the KIBO at the International Space Station (ISS) provides an ideal environment, free of the effects of gravity, for precise measurements of the thermophysical properties of high-temperature melt and for studying the metastable solidification of deep undercooled melts[1)]. Given its high oxygen solubility, liquid zirconium is typically maintained at elevated temperatures for extended durations prior to the main experiments to lower the oxygen partial pressure (P_{O2}) in the ELF chamber. The dissolution of oxygen into the sample and its oxidation affect the investigation of solidification behavior and thermophysical properties, particularly surface tension. However, the effects of P_{O2} in the ELF chamber have not been quantitatively evaluated in these space missions because the ELF does not include an oxygen sensor due to spatial constraints of the ISS.

As part of a broader initiative by JAXA to use the ELF for fundamental materials research, we have proposed to estimate the oxygen partial pressure in the ELF chamber. This will involve analyzing the relationship between the surface tension of liquid zirconium, its temperature, and the concentration of dissolved oxygen within the sample. In this presentation, we will outline the rationale, objectives, and current preparation status of our proposal.

2. Estimating P_{O2} in the ELF chamber

The surface tension of liquid zirconium is affected by the amount of dissolved oxygen and temperature, since oxygen acts as a potent surfactant[2]. We have measured the surface tension of liquid zirconium as a function of temperature and dissolved oxygen concentration using the oscillating droplet method with electromagnetic levitation (EML) technique on Earth. For example, in a typical experiment conducted at 1900 K, we observed that an increase in the concentration of dissolved oxygen from the measurement atmosphere correlates with a decrease in surface tension, as depicted in Figure 1[2-4]. By establishing a precise relationship between surface tension, temperature, and oxygen concentration, we can estimate the concentration of dissolved oxygen in liquid zirconium maintained within the ELF by analyzing the corresponding temperature and surface tension data. This estimation allows for the calculation of the corresponding P_{O2} in the ELF chamber based on the amount of oxygen dissolved from the measurement atmosphere.

Additionally, to validate the accuracy of this approach, especially in correcting for the effects of gravitational acceleration on surface tension measurements with EML, we plan to compare surface tension data of liquid platinum — which is unaffected by oxygen — measured using the EML on Earth with those obtained in the ELF. Notably, previous measurements of the surface tension of liquid platinum on Earth, utilizing both EML and ESL techniques, have demonstrated comparatively good agreement, thereby implying the reliability of these methods[5].

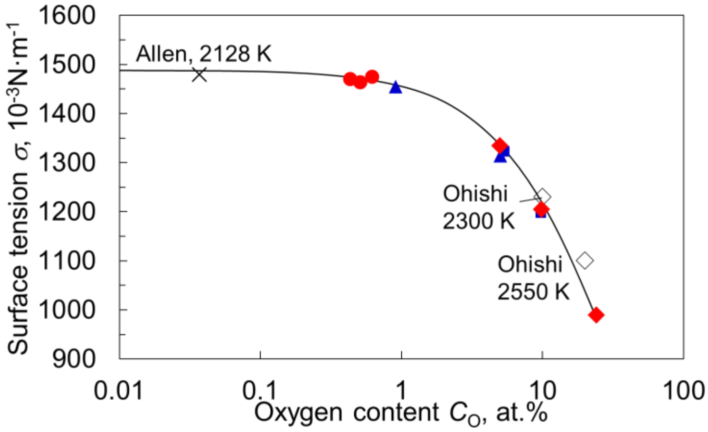

Figure 1 Surface tension of liquid zirconium as a function of oxygen content at around 1900 K measured using EML[2] with comparative literature data from Allen[3] and Ohishi et al[4].

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