# Ga Valved Knudsen Cell Flux Monitoring with the kSA ACE

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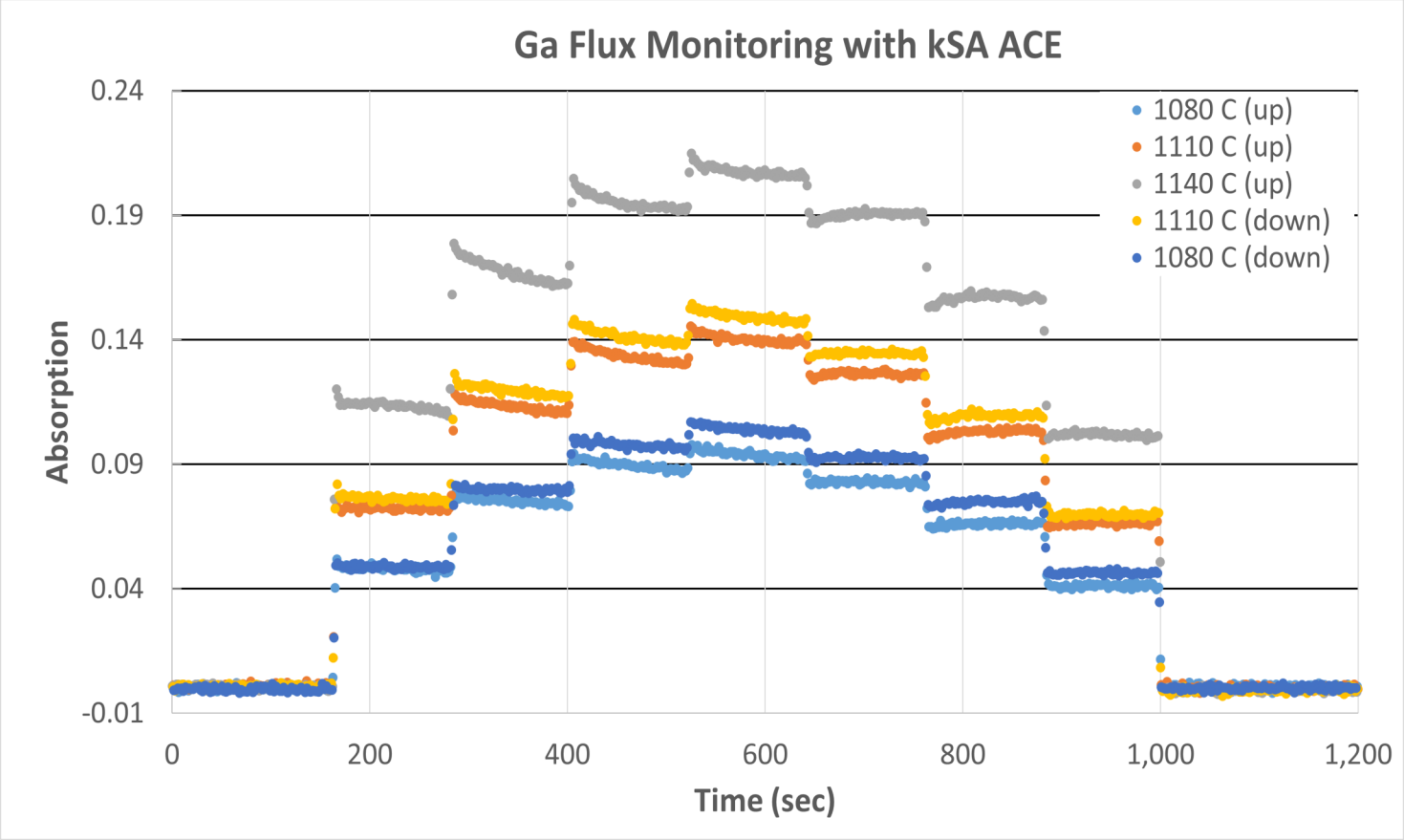
## Introduction

The k-Space kSA ACE atomic absorption (AA) flux monitoring tool was used to precisely monitor Ga flux stability of a commercially available valved Knudsen cell on a Riber 49 molecular beam epitaxy (MBE) reactor. The kSA ACE tool was mounted to AA viewports on the reactor, allowing the light beam to traverse the atomic flux just below the sample surface and monitor three elements – In, Ga, and Al – simultaneously. For this experiment, we monitored flux for Ga only, as it was the only source material that the valved Knudsen cell controlled. The Ga flux was controlled by both the temperature of the cell and the valve position setting.

## Experiment

The kSA ACE tool was used to monitor the Ga flux as the Knudsen cell was ramped up to three different temperature setpoints: 1080 °C, 1110 °C, and 1140 °C; followed by a ramp down to the same setpoints. Once the temperature stabilized for each condition (based on the cell TC reading), the valve position was opened to four different settings sequentially – 25%, 50%, 75%, and 90% – before being closed to the same settings in reverse order. This opening and closing of the valve position was performed at each temperature. Below we show the cumulative plot for this valve opening and closing at all three temperatures.



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This plot shows many interesting phenomena of the valved Knudsen cell that would not be evident without direct real-time monitoring of the Ga flux using the kSA ACE tool :

*Temperature ramp up vs. ramp down offset*. There is a significant offset in the actual atomic flux from the cell, depending on whether the system reached the temperature from a ramp up or ramp down scenario. Specifically, during ramp up, the flux is lower than during ramp down. Note that at each temperature, the cell TC was allowed to stabilize before opening the shutter and monitoring the flux.

*Flux instability*. Ideally, the flux would be stable (i.e., a horizontal line on the plot) at each valve setting. Here, we see that the flux is high as the valve setting is increased, and then it drops slightly as the valve remains open. As the valve position is decreased, the opposite occurs — the flux increases slightly as the valve remains open. Note that this effect appears to be stronger at the higher cell temperatures as well.

## Conclusions

The k-Space kSA ACE tool was used to precisely monitor the flux transients observed in a commercially available valved Knudsen cell. The experiment demonstrated that, even though the cell TC temperature is stable, the actual material flux is strongly dependent on the ramp state of the cell (e.g., ramp up or ramp down in temperature), as well as on the valve position history. These flux transients translate directly to growth rate transients and are difficult to detect with any other technique, but they can potentially have a significant impact on final device structure (e.g., thickness and performance).

***kSA ACE hollow cathode lamp (HCL) bulbs***

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