UV LithoLoop Study 7/31/08 at 19BM -- R. W. Alkire and F. J. Rotella

Dr. R. W. Alkire, Dr. N. E. C. Duke and Dr. F. J. Rotella Structural Biology Center, Biosciences Division, Argonne National Laboratory

To test the rigidity of the loop we performed a series of scans with a silicon single crystal mounted to a single loop. The crystal was a 0.2mm x 0.2mm x 0.2mm cube, mounted to the loop using Apiezon-T grease. Grease was applied to the end of the loop, not on the loop stem, and then the loop was brought into contact with the crystal, attaching it to the loop. In this study the crystal was oriented using a CCD detector, and then the Si(220) reflection was intercepted using a photodiode detector. This reflection was scanned using our normal data collection software and the Si(220) reflected intensity captured using an oscilloscope. Timing signals from the goniometer encoder were used to trigger the oscilloscope. Output of the oscilloscope was recorded to a file. All data were collected at a rate of 1°/sec, so the amount of movement can be correlated directly using time as a base i.e., 0.001°/msec.

A Cryostream 700 was used as the cold-stream source, operating at 100 K with a flow rate of 5 l min^{-1}. To change the force on the loop the cold-stream was moved in the vertical direction, starting from its nominal "centered" setting. Moving the cold-stream up in 0.64mm increments puts more force on the loop progressively, with the highest force at the bottom of the cold-stream. Because the sample is stationary, the bottom of the cold-stream corresponds to the most positive vertical cold-stream position. Five scans were taken at each cold-stream setting, with the cold-stream moved up incrementally in a single pass.

Overall, there were six cold-stream settings. The last three positions are certainly more forceful than the nominal "centered" setting, with the last one the most forceful. Normal operation should be in the area of the first 2-3 settings only.

Below are two views of how the silicon cube was mounted in the loop for study. Orientation of the loop and crystal allowed the cold-stream to hit the loop within 3 degrees of perpendicular to its face. The crystal was sitting on the face of the loop, facing the cold-stream during the measurement.

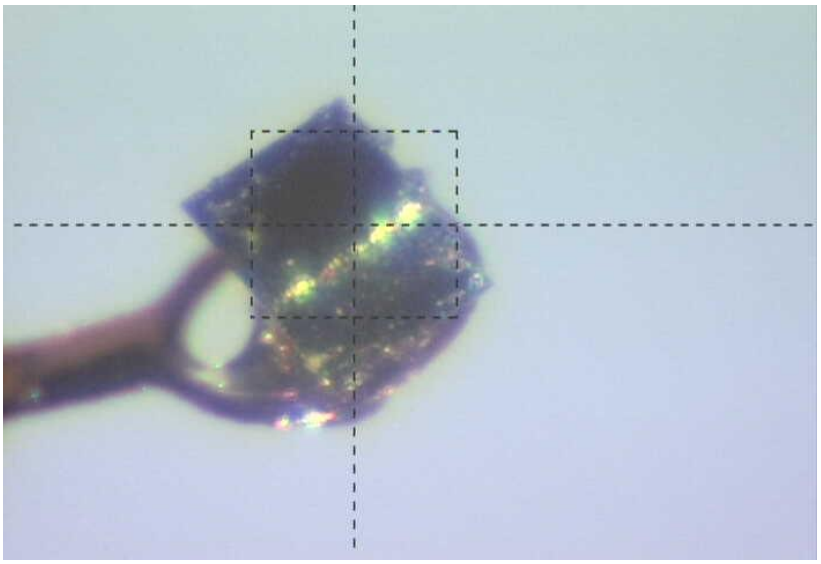

Photo1. The top camera view of the sample is taken from an elevated position (35deg above horizontal).

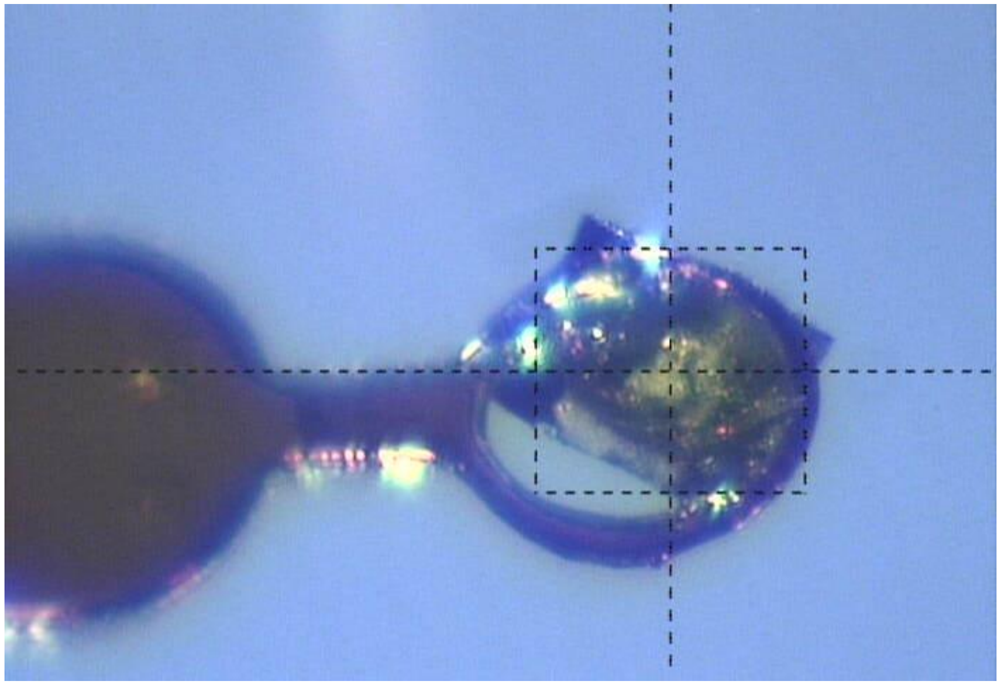

Photo 2. Bottom camera view of the sample looking at the back of the loop directly up into the crystal. The crystal and loop are oriented perpendicular to cold-stream.

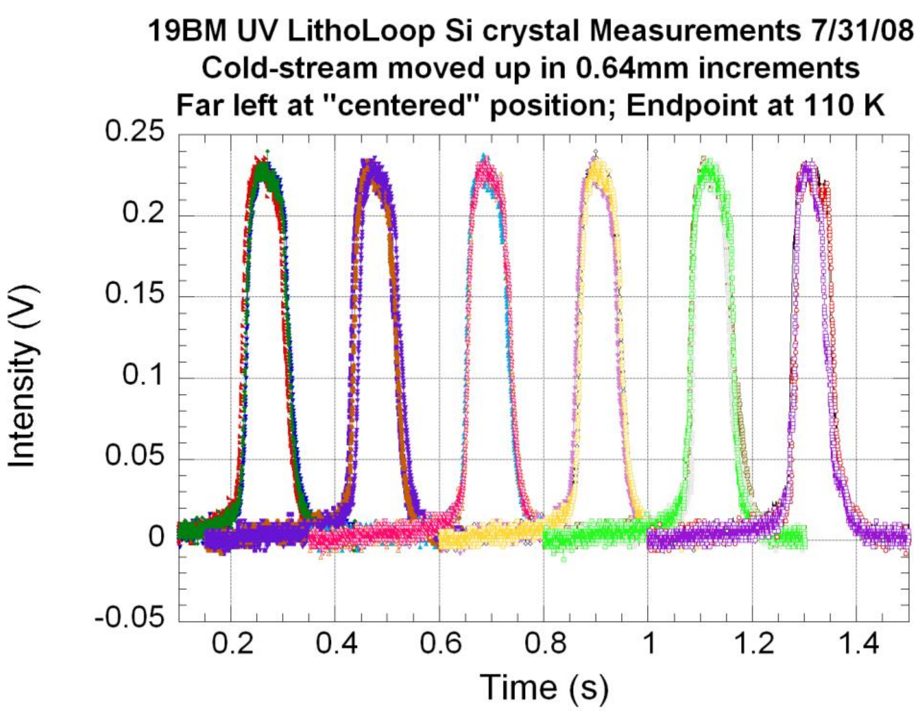

Figure 1. Peak profiles at different cold-stream positions. Force increases from left to right.

The "centered" position (far left in Figure 1) is the position that the cold-stream would normally be set to. Time is used as a convenient plot axis but each profile corresponds to an increase of 0.64mm in vertical cold-stream position. The plots are separated for clarity because they would overlap if plotted in angle or time. Although each profile group consisted of 5 scans, only three profiles are displayed for each position due to limitations of the plotting program.

As the cold-stream is raised the force increases on the loop, making it more difficult to maintain a uniform peak profile. The degree to which the profile holds its shape is a good indicator of how the loop is holding its position. Variations in position of the individual profiles also indicate whether or not the loop is holding its position.

The last two positions from Figure 1 are shown below (Figure 2) using all five scans taken at each position. These two positions represent the most forceful region of the cold-stream that we tested. The profile on the left in Figure 2 shows that the reflection centroid is not consistently in the same place, indicating that some loop movement is taking place. However, since the profiles are not too different, the loop is not bouncing around.

The right hand position in Figure 2 shows distinct differences in the peak profile, indicating the loop is moving around and causing more than a simple positional shift. The orientation of the Si crystal was within 3 degrees of allowing the face of the loop to be perpendicular to the cold-stream, allowing for maximum force on the loop. The fact that only the very last position in our scan region shows consistent breaks in the profile is a good sign that the loop is resistant to movement.

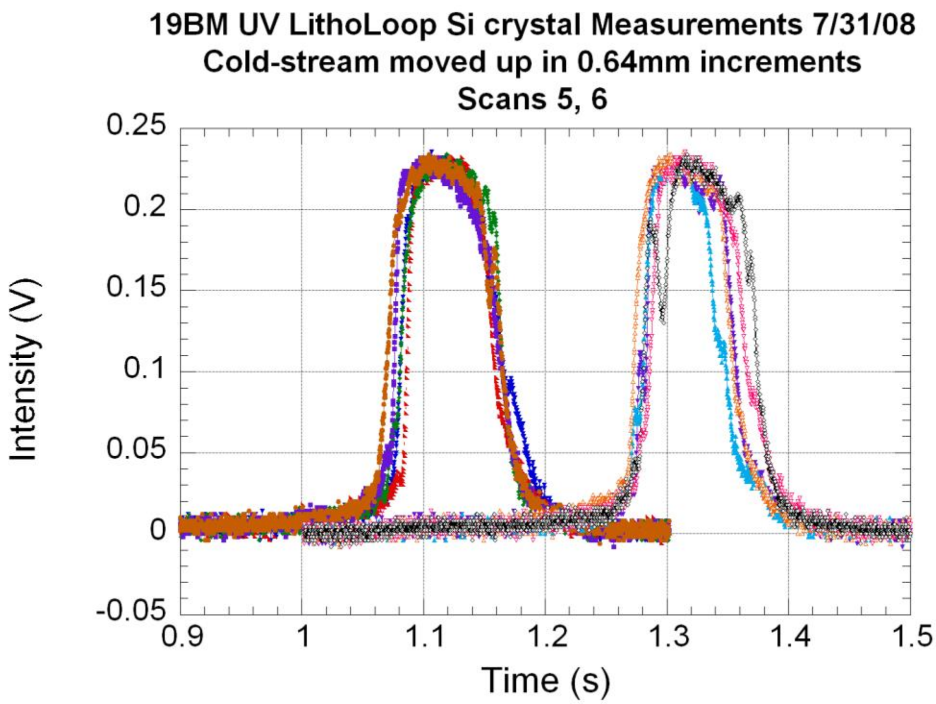

Figure 2. Peak shapes in areas of highest cold-stream force.

Variation in centroid position (Figure 3) shows that there is some loop movement with cold-stream position in general, and the error bars give a measure of repeatability inside the cold-stream. We know the linear shift is due to more than changes in the copper mounting base, since that accounts for only 0.01° of movement. However, we would put more emphasis on the peak shapes in the Figures 1 and 2. You can compare the shapes from the figures with the error bars directly in Figure 3 since they were taken from the same data.

The error bars below do not reflect the manner of loop movement, only that there was a positional shift during the measurement. Looking at the raw data gives a better account of loop flexing by way of peak shape.

It is worth emphasizing, that this analysis only pertains to these loops and not all lithographic loops. Larger or different shaped loops always have the potential for taking on different characteristics. Since the peak shapes are intact over a wide range, however, these loops look like they perform very well.

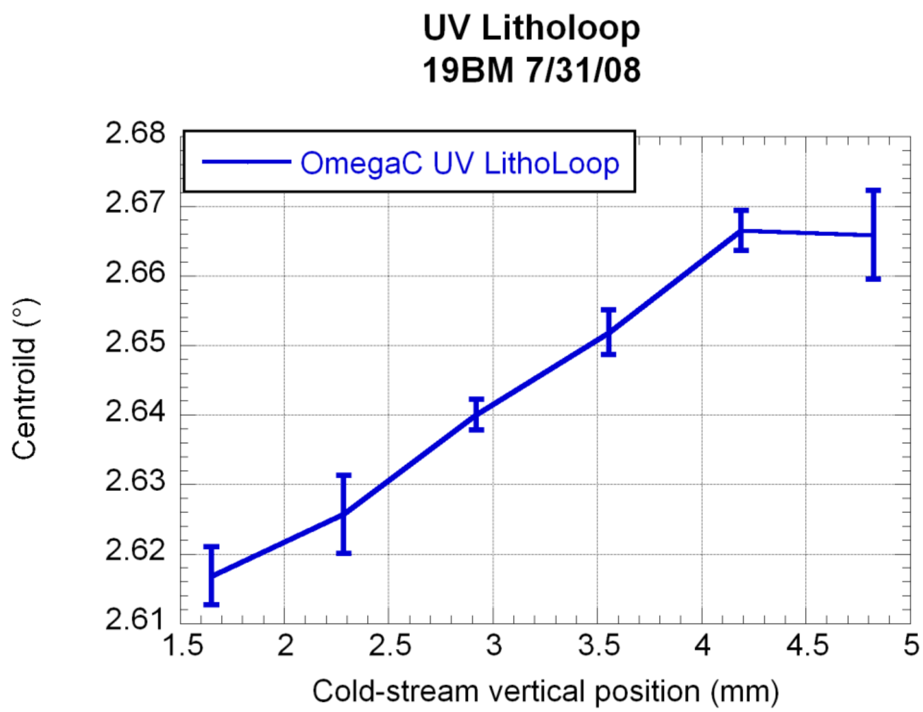

Figure 3. Angular centroid positions vs. cold-stream position. Error bars indicate movement of the reflection centroid but not how the profile may be changing.

Note: This material is a private communication and not for distribution or publication. Our future publication regarding loop movement is currently under review at the Journal of Applied Crystallography. Any references regarding this method should be directed toward the upcoming article (when published) or toward our poster presentation at the recent ACA meeting.