Lapping and Polishing Glass to Optical Smoothness

1.0: Purpose

To develop a polishing protocol for glass materials, creating an optically smooth surface finish for creating x-ray mirrors. Proper characterization of polishing pads, abrasive slurries, and processing parameters will be done for the production of high quality specimens.

2.0: Experiments and Procedures

Glass specimens of nominally 2" diameter were mounted into a Lapping and Polishing fixture using a low melting point wax. The fixture used was the Model 155, allowing 2" diameter specimens to be ground and polished to a precise depth. In this case, the specimens had been surface ground on a 120 grit SiC belt sander to make them flat. Following specimen mounting, the sample was ground on 180 grit SiC paper using the Model 920 Lapping and Polishing Machine. The sample was planarized using the 180 grit paper to make the specimen surface parallel with the lapping fixture feet, allowing a flat, polished surface to be produced. Figure 1 is an illustration of the arrangement of the polishing machine with the lapping fixture.

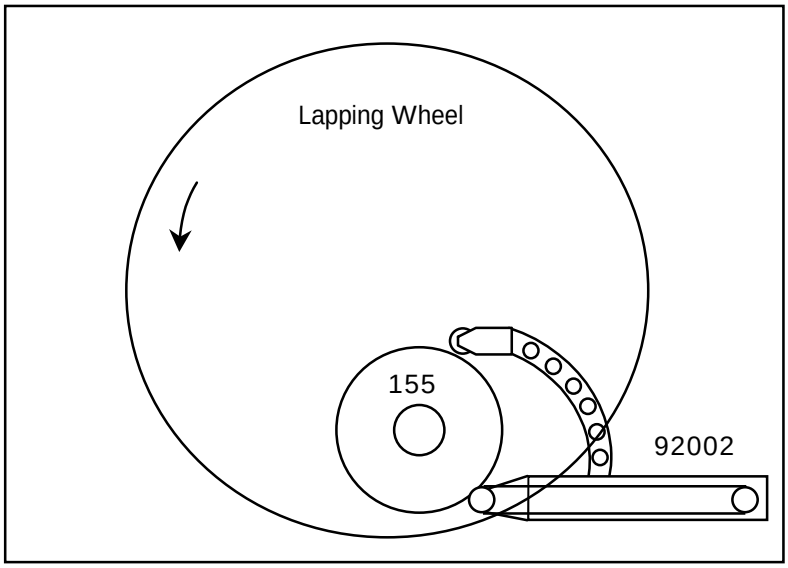

Figure 1: Illustration of the lapping wheel arrangement for performing the lapping and polishing steps.

Following the initial planarization step, the process developed included three stages: free abrasive lapping, rough polishing, and fine polishing. All three process steps will be discussed below.

Free Abrasive Lapping

Free abrasive lapping is a process by which a free abrasive (typically in a suspension or slurry of some type) is applied to a hard, flat surface. The surface is usually a soft metal or metal composite lapping plate, in this case cast Fe, which has been flattened using a truing ring. An abrasive is applied to the surface of the plate and rolls along the face of the specimen during lapping. Lapping is generally less damaging than fixed abrasive lapping, as the abrasive particles roll along and gradually break down material as opposed to the high shear forces obtained using fixed abrasives.

In this experiment, the glass sample was lapped using a 14 micron silicon carbide (SiC) abrasive slurry mixed to a standard ratio. The specimen was leveled and set to remove 500 microns of material during the lapping process. The following parameters were used during lapping:

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LOAD:	400 g	
LAP WHEEL SPEED:	4 setting	TOTAL TIME: 30 minutes
ARM ROTATION:	3 setting	
SLURRY FEED RATE:	1 drop / 5 seconds	

Rough Polishing

Rough polishing is an intermediate step which is used to remove both the subsurface damage caused by lapping and to provide the specimen with a smooth, well polished surface. Selection of the proper polishing solutions is important, the choice depending upon material being polished, polishing cloth used, and other factors.

In this experiment, the sample was polished using 3 micron diamond suspension with a Multitex polishing cloth. The Multitex cloth is a good optical polishing cloth as it is more comparable to a pad rather than a cloth, which helps maintain flatness and allows good polishing action to take place. Other polishing suspensions were used to see how they affected the specimen, but the best surface finish and material removal was obtained using the diamond suspension. A thickness of 200 microns was removed at the rough polishing stage. The following parameters were used during rough polishing:

LOAD:	300 g	
LAP WHEEL SPEED:	3 setting	TOTAL TIME: 60 minutes
ARM ROTATION:	5 setting	
SLURRY FEED RATE:	1 drop / 5 seconds	

Final Polishing

Final polishing is used as the final step to create the desired surface finish and optical quality of the specimen being polished. In this experiment, final polishing was carried out using a 0.5 cerium oxide (CeO_2) polishing solution on a Multitex polishing cloth. A thickness of 75 microns was set to be removed. The following parameters were used for final polishing:

LOAD:	150 g	
LAP WHEEL SPEED:	3 setting	TOTAL TIME: 20 minutes
ARM ROTATION:	3 setting	
SLURRY FEED RATE:	1 drop / 5 seconds	

3.0: Results and Conclusion

Based upon the polishing protocol developed, it is a relatively simple process to produce optically smooth surfaces on glass specimens using the process shown above. The polishing protocol is relatively straight forward and requires little user supervision. Completion of a single part can be done within 2 hours once the specimen has been planarized to the lapping fixture

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