



Lapping and Polishing ZnO Single Crystals to Optical Smoothness



Lapping and
Polishing

1.0: Purpose

To fully characterize the use of abrasive media, consumables, process parameters, equipment setup, and techniques used for the production of high quality polished zinc oxide (ZnO) single crystals. The crystals should be free of surface defects such as scratches following etching and should not contain defects. Determination of the proper abrasive media to use, the proper cloths for polishing, and process parameters will be done to character a suitable protocol.

2.0: Materials and Methods

The following consumable items and equipment were used for the preparation of the ZnO samples:

Equipment / Consumable Item	Description
Model 920 8" Lapping and Polishing Machine	Polishing machine used to lap and polish the ZnO wafers
Model 92002 Workstation	Semi-automatic holder used to rotate and hold the lapping fixture during instrument operation
Model 151 Lapping and Polishing Fixture	Polishing jig used to hold the ZnO samples during lapping and polishing operations
MicroDi diamond suspension (6, 3, 1 micron)	Permanent diamond abrasive suspension used for lapping and polishing
Polishing Cloths (Chemotex 1000, Multitex, Rayon Fine, Cotton Medium and Cotton Fine)	Cloths used as the surface during rough and fine polishing operations
MWH 135 Mounting Wax	Mounting wax used for wafer mounting to the lapping fixture

Three samples of approximately 10 mm x 5 mm in dimension were polished using a Model 151 Lapping and Polishing fixture used on the Model 920. The crystals contain a zinc rich phase which is the side being polished. The crystals were cleaned in acetone and alcohol prior to mounting for polishing. Each crystal was mounted onto the Model 151 using low melting point wax (MWH 135). The samples were then placed into the lapping fixture for polishing.

2.1: Crystal Mounting and Fixture Setup

Each ZnO crystal has an initial orientation that is to be maintained throughout processing. To ensure this orientation to be maintained the crystals must be mounted onto the block with high planarity. This is done by first planarizing the mounting block with respect to the tungsten carbide ring on the Model 151. The mounting block used for holding the specimen is placed into the fixture and then adjusted to remove approximately 500 microns of material. The fixture is then placed onto the Model 920 and ground with silicon carbide paper from 180 grit through 600 grit until the surface is smooth and uniform. This step is critical in ensuring a flat, parallel mounting surface to start from. Once the fixture and mounting block were established to be coplanar, each crystal was individually mounted to the mounting block using a low melting point wax. The mounting block was heated to ~ 115° C and a small amount of wax was applied to the surface. Once the wax was viscous, the crystals were placed onto the mounting block and then removed from the hot plate for cooling. Once the crystals had been mounted and cooled, the mounting blocks were then placed into the lapping fixture and zeroed. The dial on the fixture is adjusted to zero by rotating it counter clockwise, allowing the crystal to advance to the polishing surface (i.e. polishing plate). Once the crystal touches the polishing plate, the fixture is in the zero position. The fixture was then placed onto the Model 920 Lapping and Polishing Machine for preparation.

The Model 151 Lapping and Polishing fixture was held onto the machine using the Model 92002 Workstation used to hold the fixture in place during polishing and rotate it relative to the polishing wheel. This creates a much more uniform polishing action and will help in producing flat and parallel crystals. Figure 1 is an illustration showing the setup of the fixture as oriented on the polishing wheel.

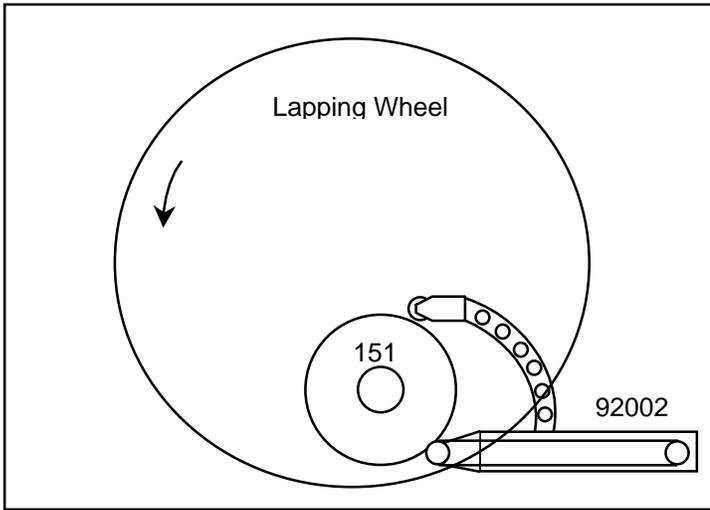


Figure 1: Illustration of the mechanical setup for polishing. The Model 151 fixture used to hold the specimen during polishing is shown held into place by the Model 92002 Workstation. The workstation holds and rotates the fixture during polishing operations creating a uniform and even polishing action over the entire surface of the crystal.

2.2: Polishing Crystals

Polishing of the crystals was done using the following steps:

Wheel Speed:	2 (105 rpm)	Load:	100 grams
Workstation Speed:	4 (17 rpm)	Polishing Rate:	3 microns / minute
Slurry Drip Rate:	1 drop / 10-20 seconds		

Several different cloths and polishing wheel setups were used to characterize the best combination of polishing rate, cloth lifetime, and flatness for doing these crystals. The following table summarizes the results obtained with the various cloths and setups.

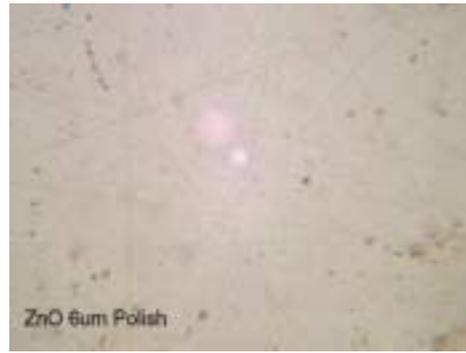
Grit Size	Cloth or Lap Type	Description
6 micron	Chemotex 1000	Showed poor surface finish; damaged the surface
	Cotton Medium Nap	Showed poor surface finish; somewhat damaged
	Cotton Fine Nap	Excellent surface finish, fair removal rate
	Multitex	Good surface finish; however appears to be primarily due to smearing of specimen material across the surface
	Nylon	Fair to poor surface finish; damage of surface slightly evident
3 micron	Rayon Fine	Exhibits excellent surface finish
1 micron	Rayon Fine	Excellent surface finish; slight edge rounding of crystal
	MultiTex	Excellent surface finish
0.05 micron colloidal silica	Multitex	Excellent surface finish

3.0: Results

Following each polishing step the specimen was cleaned with an ultrasonic cleaner and water bath. Each step was investigated using optical inspection techniques. Below are micrographs of the image following preparation.



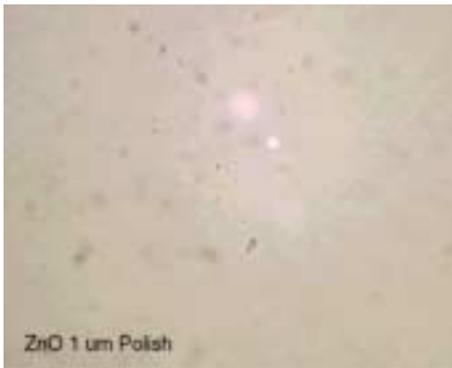
A



B



C



D

Figure 2: Images showing the polishing progression from 6 micron down to 1 micron diamond slurry. From the surface you can see that the images are getting smoother and smoother as the polishing progresses. In the final step you can see the elimination of virtually all of the surface scratches.

4.0: Conclusions

Based on the experiments conducted, the following process was developed for the successful polishing of ZnO crystals.

1. Rough polish the crystals using a Cotton Fine cloth and 6 micron diamond slurry to remove the desired amount of material.
2. Polish the crystals using 3 micron diamond slurry with a Rayon Fine polishing cloth.
3. Polish the crystals using 1 micron diamond slurry with MultiTex polishing cloth.

Investigation of the surface following polishing shows a smooth surface free of scratches. This process can easily be applied to other softer crystals which are susceptible to mechanical damage.