Lapping and Polishing $LiNbO_3$ Crystals at Specific Angles

SBT 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 polished Lithium Niobate ($LiNbO_3$) crystals at specific angles for optical applications. Wafers were cut into thin pieces and mounted onto a modified fixture to allow a specific angle to be polished. This report outlines the basics of the polishing process including fixture setup, equipment, and consumables used.

2.0: Materials and Methods

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

Equipment / Consumable Item	Description
Model 920 8" Lapping and Polishing Machine	Polishing machine used to lap and polish the crystals
Model 92002 Workstation	Semi-automatic holder used to rotate and hold the lapping fixture during instrument operation
Model 163 VersaLap™	Polishing jig used to hold the crystals during lapping and polishing operations
LP 920M	Cast iron lapping plate used for rough lapping the crystals and stock removal
Conditioning ring	Used for resurfacing of Cast iron lapping plate
MicroDi diamond suspension (9, 3, 1, 0.25 micron)	Permanent diamond abrasive suspension used for lapping and polishing
Polishing Cloth (Multitex, Cotton Fine)	Cloths used as the surface during fine polishing operations
Super Glue	Adhesive used for attaching specimens
Colloidal Silica, 0.05 micron	Final polishing solution

Several crystals were cut into thin strips of 2mm x 75mm for mounting onto the mounting block of the Model 163 VersaLap™ fixture. Crystals were cut using a Model 850 Wire Saw to prevent subsurface damage, minimize material loss, and to ensure a good starting specimen.

2.1: Crystal Mounting and Setup

Prior to crystal mounting into the VersaLap™, the mounting block was first planarized to the cast iron lapping plate using the 9 micron diamond suspension. This step is critical in ensuring each specimen will be lapped at the same angle during lapping and polishing processes. A modified mounting block was machined to create a specific polishing angle for each crystal strip. The block contains several "V" shaped grooves that are used for holding each individual crystal strip at a specific angle of 13° from the bottom of the strip. Each crystal strip was mounted to the block using super glue to prevent exposure of the crystals to thermal shock and heat effects that sometimes induce changes in optical properties. Figure 1 shows an illustration of the crystals as they are mounted onto the modified mounting block.

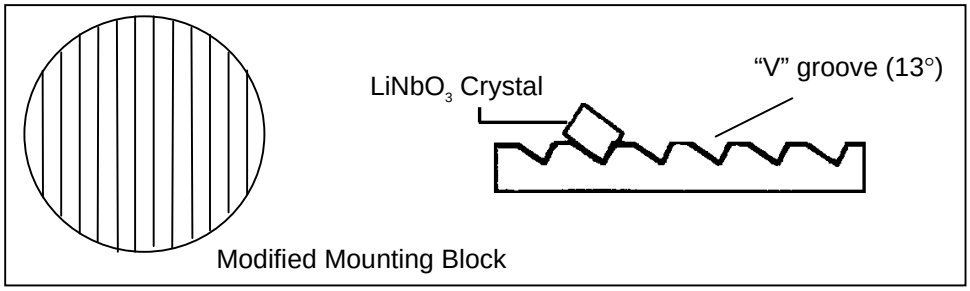

Figure 1: Illustration of the mounting block used for polishing crystals at a specific angle. The crystals are about 1.5 mm wide x 75 mm long. Each is polished at a specific angle of 13 degrees.

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Following crystal mounting the block was mounted into the Model 163 and adjusted for polishing. Only a few hundered microns were allowed to be removed and then was followed by polishing steps to remove the scratches and create a smooth, scratch free surface.

The Model 163 VersaLap™ fixture was held onto the machine using the Model 92002 Workstation which is used to both hold the fixture in place during lapping and rotate it relative to the lapping wheel. This creates a much more uniform lapping action and will help in producing high quality specimens. Figure 2 is an illustration showing the setup of the fixture as oriented on the polishing wheel during lapping and polishing processes.

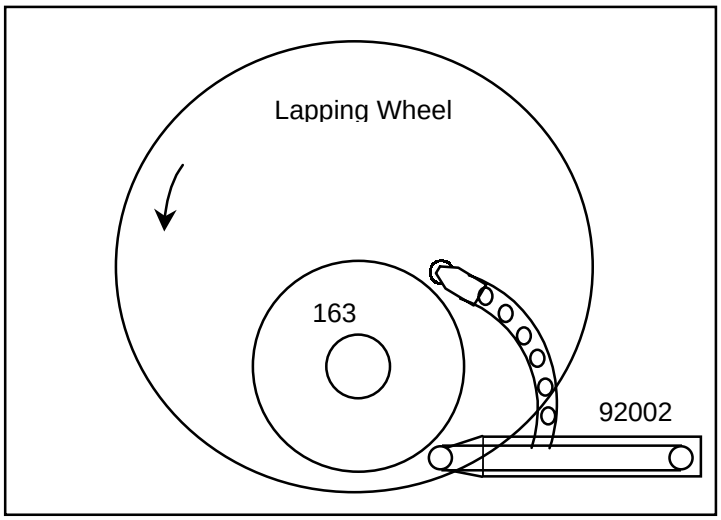

Figure 2: Illustration of the mechanical setup for lapping and polishing. The VersaLap™ fixture used to hold the specimen during lapping is shown cradled in the Model 92002 Workstation. The workstation holds and rotates the fixture during lapping and polishing operations, creating a uniform and even polishing action over the entire surface of the crystal.

2.2: Lapping and Polishing

For the lapping and polishing stages of preparation, the wheel speed, workstation speed, and slurry drip rate were all kept constant at the following settings:

Wheel Speed:	3 (200 rpm)
Workstation Speed:	5 (20 rpm)
Slurry Drip Rate:	1 drop / 10-20 seconds

Cast Iron Lapping

For bulk removal of material from the crystals and creating the specified angle desired, the crystals were first lapped using the cast iron lapping plate. Prior to lapping, the plate was resurfaced using a metal conditioning ring which removes a small amount of material from the surface of the plate. This process is done using the abrasive media being used for the lapping process (in this case 9 micron diamond slurry). Plate conditioning makes the plate surface uniformly flat and allows for precision removal of specimen material. Conditioning of the plate was done for 10 minutes followed by specimen processing.

Cloth Polishing

Following the lapping process the cast iron plate was removed and a standard aluminum lapping plate installed on the Model 920. Rough polishing of the crystals was required to remove the damage created by the lapping process and to create an optically smooth surface. Polishing using a 3 micron diamond abrasive slurry was completed with a Fine Cotton polishing cloth. The cloth provides good flatness and polishing rates for these crystals and took only about 30 minutes to remove the scratches from the previous step.

Fine polishing was carried out using the same type of process using 0.25 micron diamond slurry on a MultiTex polishing cloth. This cloth provides good flatness and high quality optical polishing to ensure that a smooth surface is created. Polishing times were on the order of 30 minutes and showed good results.

Final polishing was carried out using the same cloth (MultiTex) using a 0.05 micron colloidal silica polishing solution. This solution provides excellent surface finishes and is commonly used with a wide variety of materials. Polishing times were on the order of 5 minutes.

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3.0: Results

Preparing these crystals in a specific orientation and creating the desired surface finish was successful. By using a combination of standard lapping and polishing techniques in conjunction with precision fixturing preparation of these specimens proved to be routine. The VersaLap™ fixtures allow a wide range of specimen configurations to be incorporated into the mounting plate, allowing thin strips, wafers, and irregular shaped samples to be lapped with precision approaching the micron level.

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