Lapping and Polishing SiC Wafers

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 SiC wafers. Determination of cloth lifetime during processing, lapping and polishing procedures, and the surface finish of the SiC wafers will be done to verify process viability.

2.0: Materials and Methods

The following consumable items and equipment were used for the preparation of the 1" diameter SiC wafers:

Equipment / Consumable Item	Description
Model 920 8" Lapping and Polishing Machine	Polishing machine used to lap and polish the SiC wafers
Model 92002 Workstation	Semi-automatic holder used to rotate and hold the lapping fixture during instrument operation
Model 155 Lapping and Polishing Fixture	Polishing jig used to hold the SiC wafers during lapping and polishing operations
LP 920M	Cast iron lapping plate used for rough lapping the SiC wafers to dimension
MicroDi diamond suspension (9, 6, 3, 1, 0.25 micron)	Permanent diamond abrasive suspension used for lapping and polishing
Polishing Cloths (Chemotex 1000, Multitex, Rayon Fine, and Optipol)	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

Two SiC wafers of 1" diameter were obtained for lapping and polishing. The wafers had been rough ground to a parallelism of around +4 microns prior to lapping and polishing.

2.1: Wafer Mounting and Setup

Prior to wafer mounting into the lapping fixture, each mounting block was first planarized to the base of the Model 155 fixture using 600 grit SiC paper. This step is critical in ensuring a flat, parallel wafer following lapping and polishing processes. Once the fixture and mounting block were established to be coplanar, each 1" diameter wafer was 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 wafers were placed onto the mounting blocks and then removed from the hot plate for cooling. Wafers were gently clamped together to ensure a uniform wax layer. It is important to prevent the wafers from experiencing thermal shock or high amounts of mechanical stress, especially following the polishing operations where the intense change in temperature can cause stress induced cracking and other defects. This is prevented by allowing the wafers to cool slowly and avoiding drastic changes in temperature.

Once the wafers 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 wafer to advance to the lapping surface (i.e. lapping plate). Once the wafer touches the lapping 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 155 lapping and polishing 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 flat and parallel wafers. Figure 1 is an illustration showing the setup of the fixture as oriented on the polishing wheel.

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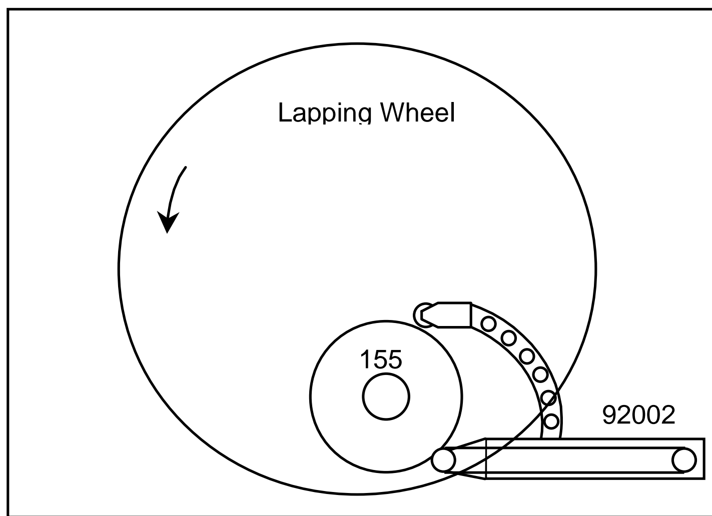

Figure 1: Illustration of the mechanical setup for lapping and polishing. The Model 155 fixture used to hold the specimen during lapping is shown held into place by the Model 92002 Workstation. The workstation holds and rotates the fixture during lapping and polishing operations, creating a uniform and even polishing action over the entire surface of the wafer.

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: 5 (385 rpm)
Workstation Speed: 5 (20 rpm)
Slurry Drip Rate: 1 drop / 10-20 seconds

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

Grit Size	Cloth or Lap Type	Description
9 micron	Chemotex 1000	Exhibited good surface finish on wafer; low grinding rate; fair lifetime and stability; good flatness
	Cast Fe Lapping Plate	Poor surface finish on wafer (although not critical in 9 micron step); high grinding rate; good flatness but needs resurfacing often; very stable
6 micron	Chemotex 1000	Good surface finish but poor removal rate; fair lifetime; good flatness
	Optipol	Excellent surface finish; good removal rates (about 2x better than Chemotex); good flatness; excellent lifetime
3 micron	Same as 6 micron	Same as 6 micron
1 micron	Rayon Fine	Excellent surface finish; poor cloth lifetime; slight edge rounding of wafer; nominal polishing rate
	MultiTex	Excellent surface finish; excellent cloth lifetime; minimal edge rounding; good flatness; nominal polishing rate
0.5 micron	Same as 1 micron	Same as 1 micron

3.0: Results

Total preparation time for these samples ranged from 4-6 hours. SiC is very resistant to abrasive actions and therefore creates many problems in terms of throughput; however, this is an experimental setup to test the lapping of SiC in general and specific aims to reduce the run times were not made. It should be noted that polishing times were quite long and the loads used during the polishing process were small (on the order of 100 grams). Lower pressures are recommended to reduce the risk of inducing dislocations or other wafer level defects which can adversely affect wafer quality and materials properties, although none of those problems were observed in this experiment.

The final specimens produced maintained the original parallelism which was measured prior to lapping and polishing, with the surface finish of the wafers matching the requirements necessary for an acceptable wafer. Care must be taken when removing the wafers from the mounting blocks following lapping as the wafers are brittle.

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4.0: Conclusions

Based on the experiments conducted, the following process was developed for the successful lapping and polishing of SiC wafers for a variety of applications:

1. Rough lap the wafers using either a cast iron lapping plate or a Optipol polishing cloth using 9 micron MicroDi diamond abrasive suspension. The abrasive suspensions are the most consistent and provide the best uniformity in polishing rate and surface finish.
2. Polish the wafers using 6 and 3 micron again using the Optipol polishing cloths. Optipol cloths provide superior flatness, lifetime, and surface finish when used for SiC materials.
3. Polish the wafers using 1 and 0.5 micron diamond abrasive suspension using the MultiTex polishing cloth. MultiTex cloths are firm backed and provide good flatness with superior final polished surfaces.
4. Wafers were held to a flatness of 4 microns across the 1" wafer diameter.
5. Using good fixturing and proper polishing cloths and media, high quality SiC wafers are produced. Low force during lapping and polishing is critical when using SiC due to the ease of dislocation generation and crack propagation.

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