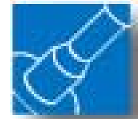
# Lapping and Polishing GaN Fiber Towers for VCSEL Applications





## 1.0: Purpose

Lapping and polishing processes are used in a wide variety of applications such as semiconductors, optics, and data communications. Use of lapping equipment enables the research and manufacturing of many current technologies, and South Bay Technology, Inc. is a leader in current lapping and polishing technology. This report outlines a precision polishing process used to produce research grade VCSEL (**V**ertical **C**avity **S**urface **E**mitting **L**aser) devices.

### 1.1: Vertical Cavity Surface Emitting Laser Basics

VCSEL, or **V**ertical **C**avity **S**urface **E**mitting **L**aser, is a semiconductor microlaser diode that emits light in a cylindrical beam vertically from the surface of a fabricated wafer. The VCSEL offers significant advantages when compared to the edge-emitting lasers currently used in the majority of fiber optic communications devices.

Traditional edge emitting lasers produce radially assymetric beams that make coupling to other optics and fibers difficult. With the VCSEL, coupling is simplified due to the radially symmetric beam output. VCSEL devices also can be manufactured on wafers and made to be very small, which is an advantage when manufacturing them.

Below are two basic diagrams outlining the two types of commonly used semiconductor lasers.

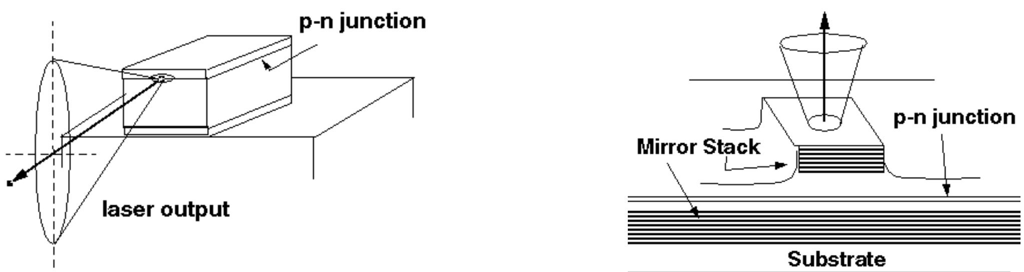



**Figure 1:** Schematic illustration of two types of semiconductor laser applications. On the left is a standard edge emitting laser with a radially assymetric beam. On the right is a vertical emitting laser (VCSEL) exhibiting a radially symmetric beam output. (Diagrams from http://www.nas.nasa.gov/~cheung/PROJECTS/VCSEL/VCSEL.html . Organization: AMTI Company Email address:cheung@nas.nasa.gov Telephone: 650-604-2875)

## 2.0: Experiments and Procedures

Sapphire wafers containing a large array of GaN fiber 'towers' extending up from the substrate were used for polishing tests. The towers are fragile and have a tendency to crack, requiring a gentle polishing process to be used. Polishing of the fiber towers was needed to produce a smooth surface in the nanometer range, a critical parameter for use in VCSEL applications where scattering due to surface roughness cannot be tolerated.

The Model 920 Lapping and Polishing Machine coupled with a Model 92002 Workstation and Model 151 Lapping and Polishing Fixture were used. Precise control of the specimen during polishing is critical when preparing materials such as these. The Model 151 was selected due to it's precision and to minimize the total force applied to the specimen during processing. This particular lapping fixture has a counter-balancing mechanism used to minimize the lapping load.

The specimen was first mounted to a stainless steel mounting block using low melting point wax (MWH 135). The wax protects the wafer and also provides a stable adhesive that is easily dissolved in acetone. The mounting block is then placed into the lapping fixture and zeroed.



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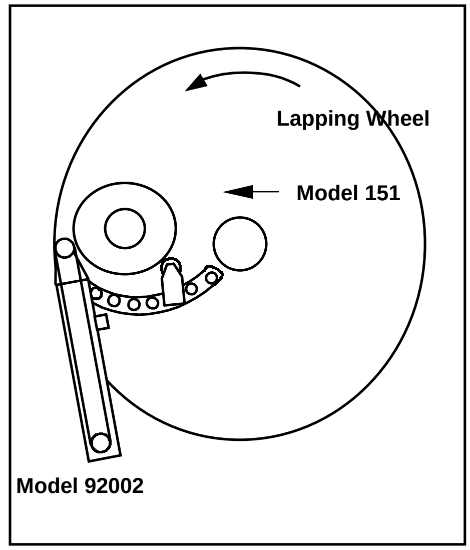
Specimen processing was done using the following parameters:

**Rough Polishing**
Abrasive: 1 µm diamond lapping film
Lubrication: $H_2O$
Plate: Glass, smooth
Wheel Speed: 100 rpm
Time: 2 minutes

**Fine Polishing**
Abrasive: 0.5 µm diamond lapping film
Lubrication: $H_2O$
Plate: Glass, smooth
Wheel Speed: 100 rpm
Time: 2 minutes

Abrasive: 0.5 µm diamond lapping film
Lubrication: $H_2O$
Plate: Glass, smooth
Wheel Speed: 100 rpm
Time: 2 minutes

**Final Polishing**
Abrasive: 0.05 µm $Al_2O_3$ on MultiTex™ Polishing Cloth
Lubrication: $H_2O$
Plate: Glass, smooth
Wheel Speed: 100 rpm
Time: 2 minutes




BASIC SETUP USED FOR POLISHING. THE MODEL 151 IS AUTOMATICALLY ROTATED WITH THE 92002 USED ON THE MODEL 920 LAPPING MACHINE

### 3.0: Results

Both prior to and after polishing the samples were evaluated in the SEM (Scanning Electron Microscope). Surface roughness measurements were taken using AFM (Atomic Force Microscopy). The specimen was processed in less than 15 minutes total preparation time.

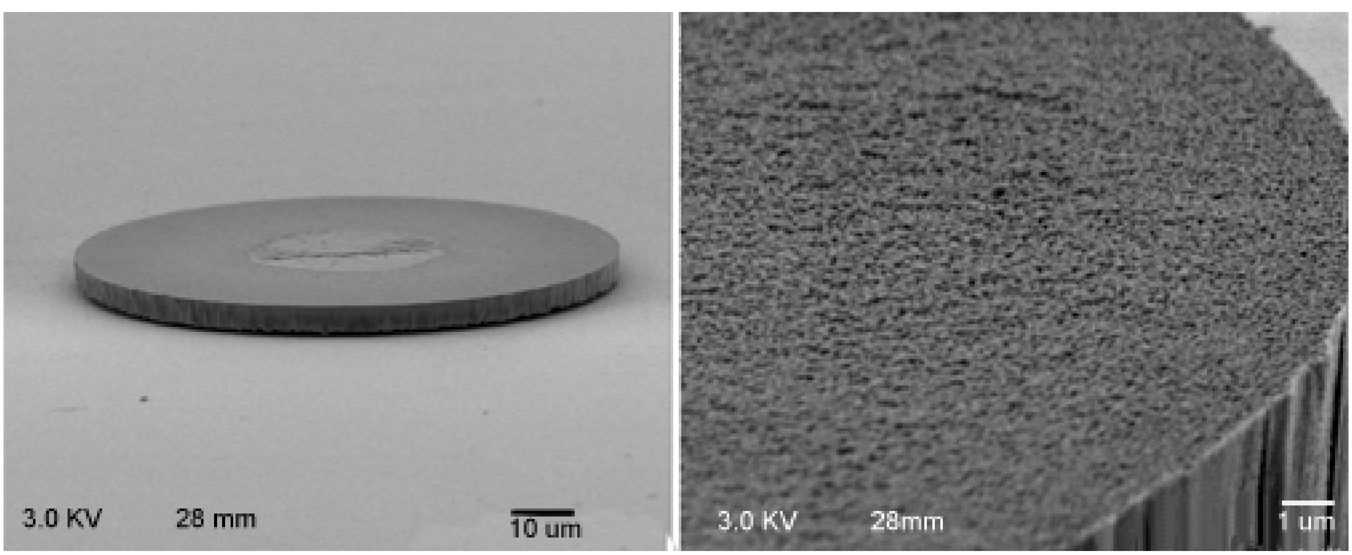



**Figure 2:** SEM image of the GaN fiber tower on a Sapphire substrate prior to polishing. The left image shows a low magnification shot illustrating the thickness of the tower. The image on the right shows the rough surface of the tower as a result of the removal from the old substrate using photo-electro-chemical-etching. The towers were bonded to the new Sapphire substrate prior to the polishing process. (Image courtesy Prof. Larry Coldren, UCSB, CA.)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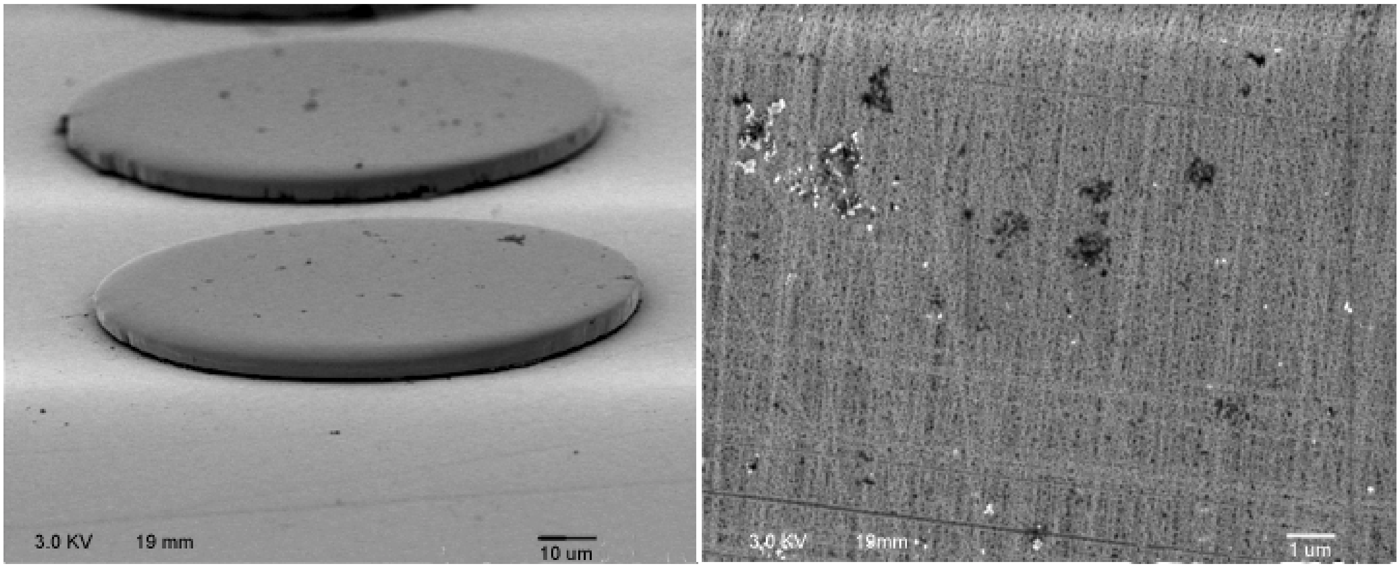


**Figure 3:** SEM image of the GaN fiber towers following the polishing process. The left image shows two GaN towers well polished and free of cracking and damage following use of the Model 151 and Model 920 polishing arrangement. The higher magnification image at right shows the surface finish of the towers which resulted in a 50Å RMS. (Image courtesy Prof. Larry Coldren, UCSB, CA.)

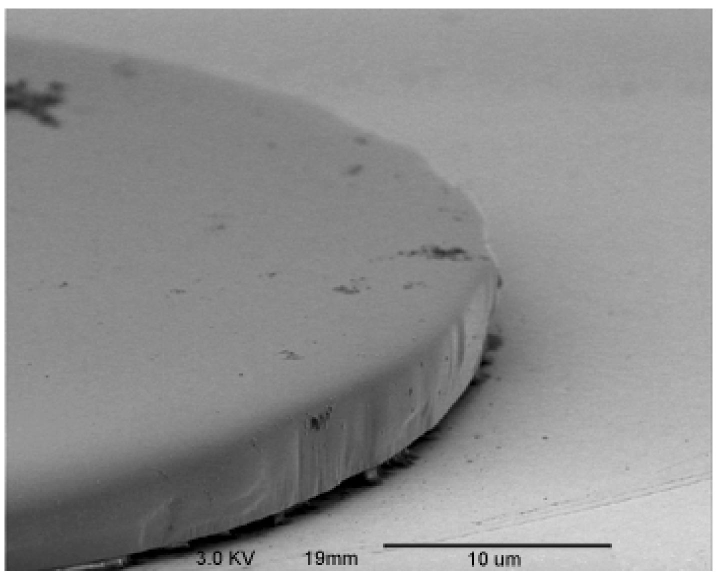


**Figure 4:** Higher magnification SEM image of the same GaN fiber towers as shown in Figure 3. The image shows good edge quality and zero damage from the polishing process, indicating excellent polish uniformity and mechanical stability. The high quality is a direct result of the lapping fixture used. (Image courtesy Prof. Larry Coldren, UCSB, CA.)

### 4.0: Conclusion

Excellent polishing results have been obtained for the production of research VCSEL materials using the Model 920 Lapping and Polishing Machine, Model 151 Lapping and Polishing Fixture, and diamond lapping films. The surface roughness of 50Å RMS without damage to the GaN fiber towers has been exhibited which is a critical factor in VCSEL applications.


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