VersaLASER Quick Guide

1. Log onto the tool in CORAL. Turn on the laser.

2. Is the correct lens installed? **If Yes----** go to step 3.

If No --- Install the other lens. Then install the solid aluminum table, and perform the manual focus. Select the new lens size in the control panel, and click the Calibrate button below the lens size.

3. Is the correct table installed? **If Yes** ---perform the manual focus (unless you just did it in Step 2).

If No --- Install the table. **Then for the honeycomb table**, perform the manual focus, and click the Calibrate button in the Cutting Table box in the control panel.

Then for the solid aluminum table, perform the manual, and click the Calibrate button in the Lens Size box.

4. Create or import a file in a CorelDraw template from the desktop. Verify that line thicknesses & colors are correct. Save the file to your folder in the USER PATTERNS folder on the desktop.

5. From "File" menu, select "Print". Select "Properties" for the VLS3.50. Input laser modes and settings by clicking the "SET" button for each color. Then click "Apply" and "OK". Click the "PRINT" button.

6. Open the VersaLASER control panel. Double-check the settings.

7. Measure the substrate thickness, and put it on the cutting table. Leave the lid open.

8. Use the "Focus" and "Relocate" views to orient the pattern on the substrate. Use the pen camera and SuperEyes software to align the pattern to pre-existing features, if necessary. (Remove the pen camera before the next step)!

9. With the lid open, use the green "Play" button to run a dummy cut. Make any adjustments.

10. Close the lid. Turn on the N_2. Click the green "Play" button to start the job. DO NOT STARE AT THE LIGHT.

11. After the job is done, turn off the N_2 and wait for fumes to subside before opening the lid. Remove the substrate and close the lid.

12. To cut the same pattern with different settings--- change the settings in the control panel. To change the location of the cut, repeat steps 8-11.

13. When finished, remove all substrates & carriers and close the software.

14. Is the cooling fan running? **If no ---** turn off the VersaLASER and log off in CORAL.

If yes ---log off in CORAL, but wait until the fan stops to turn off the laser. Notify Beth if you will not be able to turn of the laser.

VersaLaser Overview

CO_2 laser emitting in the infrared range beam width = 10.6 μm.

Spot size can be focused to: 25.4 μm --- **HPDFO optics** (red carriage)
127 μm --- **2.0 optics** (silver carriage)

Focusing sticks and a digital caliper are in labeled drawers in the white cabinet across from the laser.
HPDFO - HPDFO optics
Blank - 2.0 optics
Mitutoyo Digimatic – for either optics

Laser is emitted as a pulse. Spacing of the pulses can be adjusted (PPI = 100 – 1000 per inch).

Laser intensity is controlled by a combination of 4 settings.

Power:	0.1 - 100%	maximum is 50 Watts
Speed:	0.1 - 100%	maximum is 25 inches/min (vector); 40 inches/min (raster).
Pulses Per Inch (PPI):	100 – 1000	overlap of pulses depends on the spot size on the substrate
Focal height (z-axis):	4 inches	max intensity when focused on the top of the substrate

Tools for alignment:

1) A red diode pointer laser is on when the lid is open. This can point to where a laser job will start when a pattern is relocated to the same coordinates.
2) A pen camera and SuperEyes software can locate a alignment marks. The pattern coordinates can be adjusted to relocate a pattern to this position.

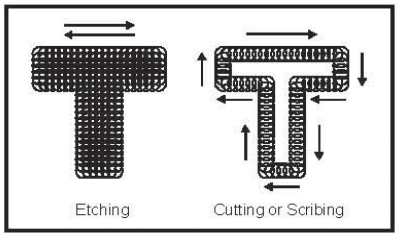
Two tables are available: honeycomb table for cutting and better removal of debris.
Solid aluminum table for etching or cutting raised samples.

A nitrogen nozzle blows at the cut site: blows away vaporized debris.
reduces flaming and combustion
reduces dust on the lens.

Aluminum carriers available for holding and aligning substrates: 4-inch wafer carrier.
Microscope slide carrier.
Carpenter square.

Etching (RASTER MODE) = laser beam scans back and forth, engraving horizontal lines as it steps down the substrate vertically. At each pass a series of laser pulses are applied to create the engraved feature.

Cutting (VECTOR MODE) = the laser beam follows a path to cut or mark a desired outline. The difference between cutting and marking is determined by the laser intensity.



RASTER VECTOR

CorelDraw Instructions (typical settings for cutting are in red):

Colors: custom color palettes are supplied:

VERSALASER.cpl- has 4 colors and 4 grays for the materials database settings.

ULS.cpl - has the 8 colors and grayscale shades for the manual settings.

For some reason, this palette title shows up as a blank title on the palette menu.

Line (pen tool) and fill (paint bucket tool) features:

- Vector mode (cutting and scribing) requires hairline width lines, no fill.
- Raster mode (etching) requires wider line widths and/or filled patterns.

CorelDRAW templates on the desktop with default settings for the laser.

-USER PLAIN TEMPLATE – blank table.
-USER SQUARE TEMPLATE – carpenter square is laid in the top left corner.
-USER WAFER TEMPLATE – wafer holder is laid in the top left corner.

Get rid of the orange guidelines or set the orange color to the "SKIP" mode before printing. This will make it easier to move your pattern in the laser control panel. And it will avoid cutting the guidelines into your pattern.

AUTOCAD and L-edit Instructions

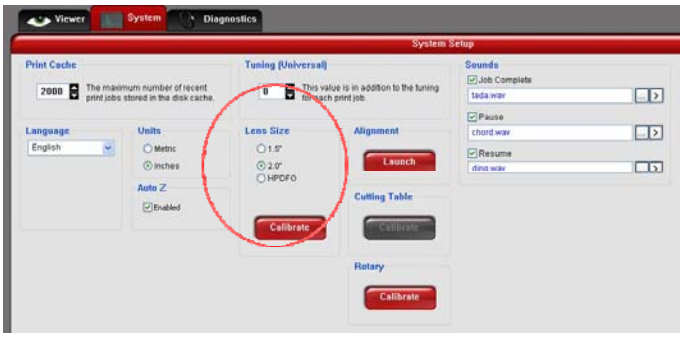
For a .TDB file, use LinkCAD (in CAD room) to convert to a .GDS first.

Convert the file to a .DXF and import it into CORELDRAW.

Ensure objects are correctly scaled, lines are the correct width and colors are in the correct palette.

Manual Focus --- If the correct lens is already installed

1) Verify that the appropriate LENS SIZE is selected in the "System" tab. *If it is not currently selected, or if you're switching the lens, follow the procedure on page 5. Newly installed lenses must be focused first on the solid aluminum table.*



2) Use the RIGHT and LEFT arrows on the "Viewer" tab to move the lens to part of the table that you'll be using.

3) Focus the laser beam: You have 2 options …digital caliper or focusing stick.

Option A) Digital Caliper: DON'T MOVE THE LENS CARRIAGE PAST Y =240 OR YOU CAN CRASH THE CALIPER.

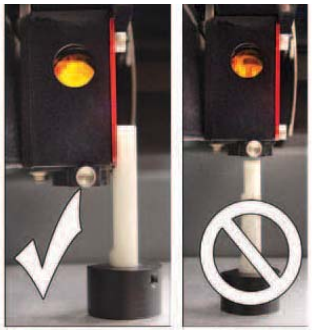
- Turn on the caliper, and mount it flush and level to the faceplate.
- Put a silicon wafer under the caliper if you're focusing on the honeycomb table.

Adjust the table height until the caliper measures:

2.0 ± 0.2 mm	**HPDFO lens (Red) on wafer/ Honeycomb table**
1.4 mm	**HPDFO lens (Red) on Solid aluminum table**
2.7 ± 0.2 mm	**2.0 lens (silver) on wafer on Honeycomb table**
2.1 mm	**2.0 lens (silver) on Solid Aluminum table**

(Variation is due to a tilt and damage to fins. Upper left side requires higher values.)

Option B) Focusing Stick: DO NOT JAM THE FOCUS STICK UNDER THE MOUNT BAR OR THE UNDERSIDE OF THE LENS, OR YOU CAN BREAK THE Z-MOTOR !!!



-Adjust the table height so that the flat edge of the focusing stick rests against the front, far left side of the lens faceplate.
-Hold the stick lightly against the faceplate, and raise the table until the tool tilts or slides away from the faceplate. The objective is to stop moving the table at the point where the tool just starts to move or tilt.

4) In the "System" tab, click the "Calibrate" button for the appropriate table to accept the new focal height. Click "save". Overwrite any old height.

-"Cutting Table" box **(black arrow)** for honeycomb table.
-"Lens size" box **(blue arrow)** for the solid aluminum table.

5) Lower the table at least 3 mm, and then remove the caliper or focus stick.

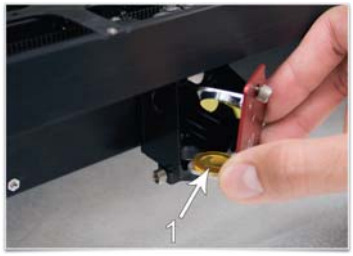
Manual Focus --- If you must change the lens

1) Verify that the wrong LENS SIZE is selected in the "System" tab.

2) If the honeycomb table is installed, lower it all the way and lift it out using the 2 side screws as handles. Don't bump the optics or the air cone. Install the solid aluminum table. Be sure it is lying flat and secure the screws.

3) Unscrew the 2 thumbscrews on the faceplate of the lens. Switch it with the other lens in the drawer (in the white cabinet across from the laser.) *Avoid touching the lens.*

Red faceplate = HPDFO Optics
Silver faceplate = 2.0 Optics



4) Use the RIGHT and LEFT arrows on the "Viewer" tab to move the lens to part of the table that you'll be using.

5) Focus the laser beam: <u>You have 2 options …digital caliper or focusing stick.</u>

Option A) Digital Caliper: DON'T MOVE THE LENS CARRIAGE PAST Y =240 OR YOU CAN CRASH THE CALIPER.

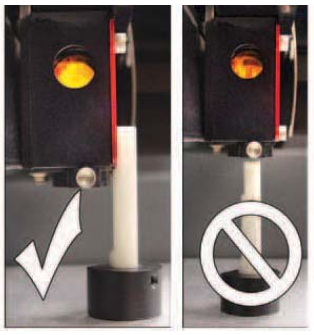
- Turn on the caliper, and mount it flush and level to the faceplate.
- Put a silicon wafer under the caliper if you're focusing on the honeycomb table.

Adjust the table height until the caliper measures:

2.0 ± 0.2 mm	**HPDFO lens (Red) on wafer/ Honeycomb table**
1.4 mm	**HPDFO lens (Red) on Solid aluminum table**
2.7 ± 0.2 mm	**2.0 lens (silver) on wafer on Honeycomb table**
2.1 mm	**2.0 lens (silver) on Solid Aluminum table**

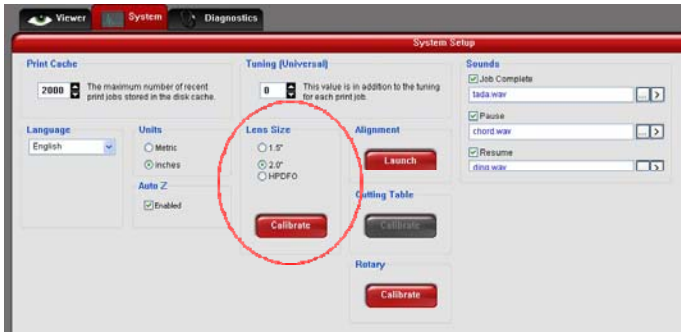
(Variation is due to a tilt and damage to fins. Upper left side requires higher values.)

<u>Option B) Focusing Stick</u>: DO NOT JAM THE FOCUS STICK UNDER THE MOUNT BAR OR THE UNDERSIDE OF THE LENS, OR YOU CAN BREAK THE Z-MOTOR !!!

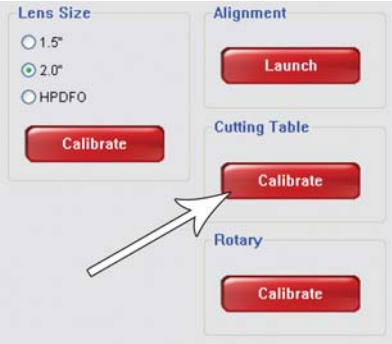


-Adjust the table height so that the flat edge of the focusing stick rests against the front, far left side of the lens faceplate.
-Hold the stick lightly against the faceplate, and raise the table until the tool tilts or slides away from the faceplate. The objective is to stop moving the table at the point where the tool just starts to move or tilt.

6) In the “System” tab, select the appropriate Lens size. Click on the red “Calibrate” button. Click “Save” in the window that appears to accept the new Z position. The lens is now focused, and the solid aluminum table is also in focus.



7) **If you need to switch to the honeycomb table for cutting**,
-Lower the table at least 3 mm and remove the caliper or focus stick.
-Move the optics to the upper right corner.
-Lower the aluminum table all the way, and remove the table.
- Insert the honeycomb table using the screws as handles.
-Jiggle the table gently until the table rests flat.
- Repeat steps 4 and 5 to focus on the honeycomb table.
- In the “System” tab. Click the “Calibrate” button in the “Cutting table” box.
-Click “Save” and overwrite any old Z-position.



Measuring substrate thickness on the laser table

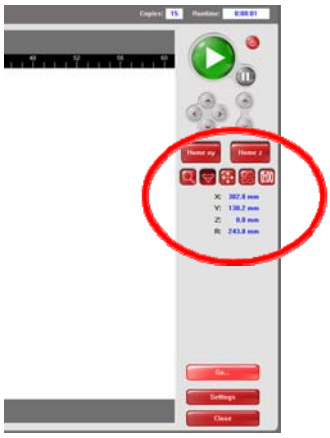
If it is difficult to measure the actual height of the surface to be cut, you can use the round digital caliper or focus stick to measure the thickness of your substrate on the laser table. *The optics should already have been focused on the table.*

Option A): Using the round digital caliper
DON'T MOVE THE LENS CARRIAGE PAST Y =240 OR YOU'LL CRASH THE CALIPER.

1) Lower the table at least 5 mm from the focal height.

2) If using the honeycomb table, place a wafer on the table under the optics carriage.
This isn't necessary with the solid aluminum table.

3) Turn on the caliper, and mount it flush and level to the faceplate.



4) Raise the table until the caliper just registers a value.
Note the **base Z height** on the "Viewer" screen (red circle).

5) Lower the table, and place your substrate on the table (or on the wafer If using the honeycomb table.

6) Raise the table until the caliper just registers a value.
Note the **substrate Z height**.

7) **Substrate Z height – base Z height = Substrate thickness.**
Enter this value as Z-height in the settings.

Option B): Using the Focus stick
DON'T JAM THE FOCUS STICK UNDER THE MOUNT BAR OR THE UNDERSIDE OF THE LENS. YOU CAN BREAK THE Z-MOTOR !!!

1) Lower the table at least 5 mm. Place the substrate on the table, and move the lens carriage over the substrate.

2) Place the correct focusing stick on the substrate, and raise the table so that the flat edge of the focus stick rests against the far left side of the optics faceplate.

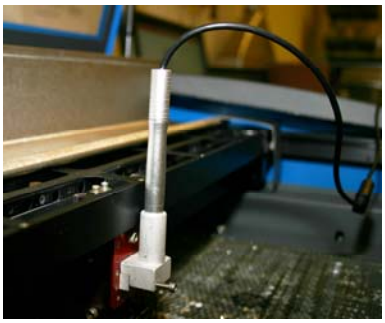
4) Use the up and down arrows in the control panel viewer tab to raise the table until you observe the stick either tilting or sliding away from the optics carriage. The objective is to stop moving the table at the point where the tool just starts to move or tilt.

5) Note the Z value on the "Viewer" screen (red circle, shown above). This is the substrate thickness.
Enter this value as Z-height in the settings.

Pattern Alignment

YOU SHOULD ALREADY HAVE PERFORMED A MANUAL FOCUS.

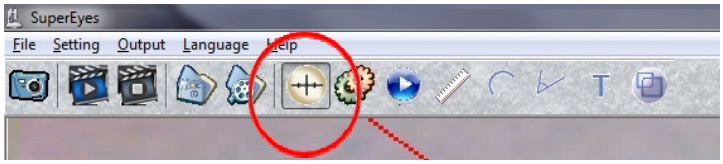
Mount a pen camera to the lens carriage to locate alignment marks and get coordinates on the laser table. The variance about 200 µm. This depends on how stably the camera is mounted and the limitations in movement of the laser belt system. **The pen camera protrudes from the top of the lens carriage. Don't close the laser lid. Don't move the lens close to the back of the laser or the aluminum lid will shut on the camera.**



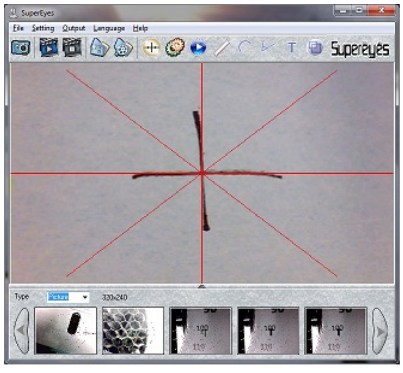
1) Send your pattern file to the laser. Load the substrate. Open the laser control panel. Activate the "Focus" control. Drive the lens carriage over to the substrate.

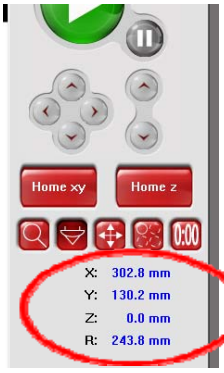
2) The pen camera is stored in the white cabinet across from the laser. Plug it into the USB cable extender on the front of the computer. Mount the camera and finger-tighten the screws making sure the camera is level and flush.

3) Click the SuperEyes icon on the desktop to open the camera. Drag the window to the right monitor. Maximize the window, and click on the marker button to show the crosshairs. Focus the camera by gently twisting the top end.



4) Activate the focus button in the laser Control panel, and use the arrows to center the alignment mark under the camera crosshairs. Note the X and Y coordinates in the laser control panel.

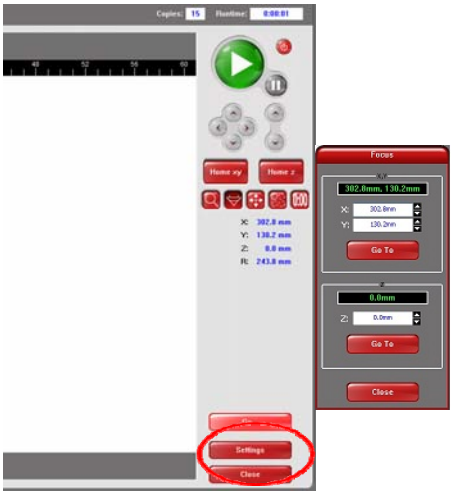




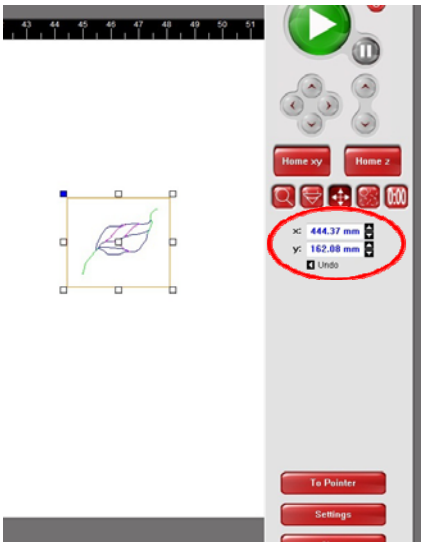
5) Remove the camera. Close the aluminum cover.

6) Move the laser pointer to the same coordinates by increasing the X and Y coordinates by the following and entering these values in the “Go To” button. The red pointer should then point to the alignment mark. Close the focus window.

HPDFO (red) lens carriage **X +3.9 mm Y +32.1 mm**
2.0 (silver) lens carriage **X +3.6 mm Y +31.7 mm**



7) Activate the “relocate” button.
Move the pattern to this position by entering the adjusted coordinates in the “Relocate” control. You are actually relocating whichever bounding point is shown in blue.



8) Run a dummy cut with the laser cover open. Close the lid. Turn on the nitrogen, and run the job.

IMPORTANT THINGS:

1) Never intentionally cut into the table. Always set the laser focal height (z-axis) above the table.

2) Check that the installed optics carriage matches what is selected in the Lens Size box in the System tab.

3) Run N_2 while the laser is cutting/engraving, and turn the N_2 off right after the job is finished.

3) Don't turn the laser off if the cooling fan is running. Log off the tool, but return later when the fan has stopped to turn off the laser. Or let Beth know you want help with turning off the laser.

4) Some substrates emit toxic fumes. If the substrate is smelly, leave it in the tool for 1 minute after cutting to allow fumes to dissipate. If the substrate continues to outgas (common for acrylics), work with it in the solvent hood and carry it in a sealed box.

5) Some substrates are prohibited because they emit corrosive gas when cut that damages the laser. These include any halogenated (chloride-containing) polymers.

Setting Suggestions & Tips:

- Always calibrate the table height before starting.
- Setting suggestions are given in the next section. Start with a 8% power, 15% speed and 500 PPI if you don't know where else to start.
- Select "NONE" as the vector optimizer option in the Vector Sub-tab. Otherwise, complex features will be written inaccurately.
- Setting the MODE for a color must be done in the preferences tab of the printing dialog box. It can't be switched for a job that has already been sent to the laser.
- The stamp mode in the raster sub-tab will add side tapers to the vertical edges of features. You can also change the shapes of the tapers.
- For materials that are thicker than 0.5 mm, try stepping cuts into the substrate by progressively DECREASING the z-height. The HPDFO optics will lose focus within 300 microns so be sure to be within this range when stepping to a different height during a job.
- Speeds faster than 15% often cause irregularities due to the shaking caused by the moving plotter.
- Passing over the same area twice may clean up the edges on some polymers like PET.

VECTOR CUTTING:

Determine the nominal intensity setting

The fine focus of the table, the cleanliness of the optics or the lifespan of the laser can change this setting day-to-day.

1. Place the laser focal point on the surface of the substrate. This can be set to 100 micron increments by focusing on the cutting table and entering the substrate height (thickness) in the z-axis setting.

-or-

You can focus directly on the substrate by placing the focusing stick on the substrate.

2. In COREL draw, make an intensity grid file with the 8 colors from the ULS palette for different laser intensities. Make the features in the grid match the types of features in your device (i.e. vertical or horizontal lines or curves, for instance). Enter a range of laser power settings (1, 5, 10, 15, 25, 35, 50, and 75, for example) all with the same speed, PPI and z-axis. Run the job and repeat while fine-tuning the power or speed to determine the lowest intensity to get an acceptable cut with minimal damage to the surrounding area on your substrate. This is the NOMINAL INTENSITY setting.

3. Tailor nominal intensity settings for various features in the device. For instance, (1) a cut-out with smooth side walls in PET will require a second cut with a greater PPI to smooth the edges, (2) a serration (partial cut) will require less power, and (3) a quick cut out of the entire device that doesn't need to be as smooth can be run with a greater power and faster speed. Each of these features should be drawn in a different color.

Determine the line width(s)

The width and depth of a cut will vary by (1) laser intensity and the (2) substrate.

Once you have decided on an intensity setting for each feature (color). Run the job and measure the line widths of each cut. Thermoplastics like PMMA will melt back and give a much wider line than the beam width while stable elastomers like PDMS will yield lines that are less than twice the width of the beam. Factor the line widths into the design and alter the computer dimensions to yield the final desired dimensions. For instance, in PET, a 3.6mm x 19mm rectangular cut-out at a certain intensity may need to be reduced by 100 microns on all sides if the line width is 100 microns. If the laser intensity or the substrate are subsequently changed, the line widths will also change.

RASTER ENGRAVING

Enhancement and tuning

Raster engraving yields many artifacts at the microscale including:

- Horizontal lines along the bottom of the engraved feature from the traveling laser beam
- Tapered edges along vertical sides of engraved features
- Scalloped edges along the vertical sides of engraved features.
- Irregular topology (roughness) on the bottom of engraved features
- Wobbly vertical edges
- Widened features (edges of adjacent text touch, for instance).

Use the controls in the RASTER Sub-tab to minimize artifacts.