University of Minnesota -- Minnesota Nano Center

Standard Operating Procedure

Equipment Name: Disco wafer dicing saw
Badger Name:saw-disco 552
Revision Number: 9
Model: Disco DAC-552
Revisionist: Kevin Roberts
Date: 3-11-2022
Location: Area 1

1 Description

The DISCO DAC-552 can cut 4 inch (1 mm thick) substrates made of silicon, glass, Pyrex or sapphire. **No 6 inch substrates, ultra-thick substrates, or hazardous substrates (i.e. GaAs, PZT….) can be cut on the wafer saw.**

2 Safety

a. **Always wear safety glasses** whenever the spindle is on and the safety cover is open! Blade spins at 25 krpm! A blade failure can throw many sharp particles from the spindle.
b. Do not open the safety cover when the saw is cutting.

3 Restrictions/Requirements

a. Must be a qualified user on the Disco wafer saw.
b. **Allowed substrates**: 4 inch diameter, up to 1 mm thick silicon, glass, Pyrex, and sapphire.
Not-Allowed substrates: 6 inch substrates, ultra-thick substrates, hazardous substrates (i.e. **GaAs, PZT**)
c. Enable/Disable the "saw-disco 552" in Badger with each use.

4 Required Facilities

a. Compressed air, 80 psi
b. Chilled water, 1 GPM
c. DI Water
d. vacuum, -22 in. Hg

5 Definitions

Mounting: Substrates must be mounted on dicing tape if they are going to be cut all the way through. MNC has two types of dicing tape that are available for users. The tape must be placed tightly on the mounting frame. No wrinkles, gaps or sagging areas should be visible on the tape once it is mounted on a frame. Sagging areas will affect the height of the cut and the accuracy of the cutting path. Adhere the back of the substrate to the tape. Avoid getting bubbles between the tape and your substrate, as bubbles will affect the height of your cut and the accuracy of the cutting path.

Blue Tape (**Thickness = 75 µm):** This tape has a medium tackiness and should only be used for cutting out die that are least 1cm x 1cm. Smaller die may fall off this type of tape.

Set the "Blade Height" to 0.060 mm when using the blue tape. The cut will go through the top 15 µ of tape (to ensure that the wafer has been cut through completely).

Clear "UV" tape (Thickness = 120 µm): This tape has a high tackiness and should only be used for cutting out die that are smaller than 1cm x 1cm. The tape will need to be exposed to UV light on the ORIEL for about 5+ minutes to release the adhesive.

Set the "Blade Height" to 0.090 mm when using the clear "UV" tape.

Cut Water: This refers to the water that sprays out of a number of nozzles onto the blade and onto the substrate during cutting.

Kerf: This is an estimate of the cut width. It can vary slightly depending on different variables. See the Disco Saw "blades and flanges" section on the last page for more info on this, including how the kerf differs with the type of dicing blade used.

6 Operating Instructions

a. **Blade Check:** Depending on your dicing needs, you may need to request a blade-change by emailing the proper MNC personnel. If this is needed, send an email to both Kevin Roberts (rober074@umn.edu) and Glenn Kuschke (kglenn@umn.edu) explaining which blade you want (the "everything" dicing blade or the "silicon" dicing blade) and also explaining when you plan on using the saw. Kevin is going to be the primary person to perform blade changes but if he is unavailable, then Glenn may be available to do so in Kevin's absence, which is why you should email both of them. Once the blade has been changed by the proper MNC staff personnel, that staff member will enter a comment in Badger indicating which blade is currently installed. This is going to be your indication that the blade has or has not been changed, so ALL USERS should check the comments in Badger to see which blade is currently installed on the system prior to using the dicing saw. You should also physically check which blade is installed on the spindle.
   Make sure the blade doesn't appear to be **chipped or broken.**

b. **System Enable:** Enable the "saw-disco 552" in Badger.

c. **Spindle Check:** Open the left safety cover (if it is not open already) by lifting up on the black handle until the cover is fully opened. You should hear air hissing out of the end of the spindle hub and this will become louder and more noticeable with the safety cover open. **Check that the spindle is not seized** by rotating it at least a full revolution, manually by hand.

You will notice that about every quarter-turn (every 90 degrees of rotation) the spindle seems to settle into a more rigid position. This is a normal attribute of this type of air spindle, and so you won't normally be able to freely spin the spindle for more than a couple of revolutions before it stops rotating on its own. This is to be expected. If however, the spindle doesn't rotate freely at all (every quarter-turn), then shutdown the saw in Badger and **DO NOT USE** the saw or it could further harm the machine and possibly harm the operator.

d. **EMO button**: If there is any emergency that occurs during the operation of the saw such as visible smoke, sparks, fire, or any other sign of danger or equipment failure (e.g. grinding noises), please press the red **EMO** button (see image below):



Ensure that your hands are free and clear from any moving parts in the chuck or spindle area and exercise great caution whenever the spindle is rotating and/or whenever the safety covers are open.

e. **System Start-up:** Turn on the system using the power keyswitch, located to the right of the computer monitor. Turn the keyswitch from the **OFF** position to the **START** position and hold it there for a second or two. Once you release the keyswitch, it should spring back to the **ON** position. The computer monitor and the rest of the system electronics should turn on at this point.

If any errors appear at this point, note the description of the error displayed, report the error description in Badger, turn the power keyswitch to the **OFF** position, and **DO NOT USE** the system.

During the start-up you may notice that the chuck and spindle begin to move as the system performs its own initialization steps. Once the initialization is complete, the main menu should appear which lists the four following options:

1. **SET UP LIST**
2. **CUT PROGRAM ENTRY**
3. **FUNCTION SET**
4. **OTHER**

f. **Spindle Start-Up:** The appropriate blade required to cut your type of substrate should already be installed on the spindle before proceeding, and the blade should be checked for any visible damage (as mentioned previously in step '**a'** of this SOP).

Wear safety glasses before proceeding. Open the left safety cover (if it isn't open already) so that you can see the spindle and the cut water nozzles.

Ensure that your hands are free and clear from any moving parts in the chuck or spindle area and exercise great caution whenever the spindle is rotating and/or whenever the safety covers are open.

Turn **ON** the spindle rotation by pressing the **SPNDL** button (see image below):



You may hear a loud click sound after turning on the spindle rotation. This is a safety solenoid that will be used later to secure the left safety cover during dicing. The spindle should ramp up.

g. **Programming a "Cut Program":** On the keypad, press the number '**2'**, to enter the **Cut Entry** screen from the main menu. The **Cut Entry** screen contains a list of stored "Cut Entries" (i.e. program numbers) which are labeled as C01, C02…all the way up to program number C30.

Under the left column of cut entries you will see a data entry field titled:

>> **PROGRAM No. [____]**

Type in the number of the cut program that you want to edit (for example 1, 2, 3, etc.). Program number 1 is used most often and can be edited by any user at any time. Once you've entered the desired cut program number, press the **ENTER** button to access that cut program.

Once you enter the program screen for a particular cut program, you will be able to edit various parameters pertaining to the spindle, the X and Y axes, dicing pitch, rotation, etc.

Ensure that the cut program parameters are set according to the following table:

Parameter Name	**Required Value (if any)**	**Parameter Description**
Unit	mm	This selects the units of measurement for all values in this program pertaining to length, height, depth, cut speed (mm/sec), etc.
ID	Example: 'ANY_USER'	This ID is the name of the cut program entry. Do not change the ID for program number 1. To change an ID, move the cursor to this parameter and press **ENTER**. Once the keyboard pops up on the screen, you can move the cursor to each desired character and press **ENTER** to add that character to the ID. Then move the cursor to the END option and press **ENTER** to save the recipe ID. Press **ESC** if you don't want to save any changes made.
Cut Mode	A	This 'A' mode designates cutting from left to right on your substrate. This setting should not be changed.

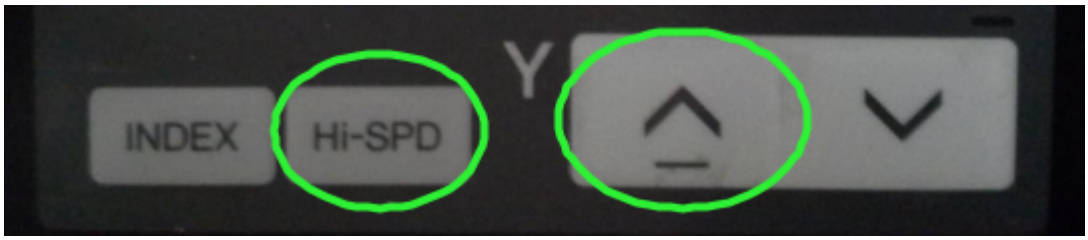
Work Size Pattern	S	This 'S' pattern designates that the cuts are performed in a square / rectangular shaped array.
W	Example: 100 (mm)	This is the **length** of your cut and should be at least 10 mm larger than your actual substrate's width in order to compensate for any error in centering your wafer on the mounting tape. For example, if you have a 100 mm substrate, then you should set this parameter to '110' (mm).
H	Example: 2.0 (mm)	This is the **height** that you want the blade to go up to **AFTER** performing a cut, while it travels to the starting position of the next cut line. Since the blade needs extra clearance to move above and over your substrate, setting this to '2' (mm) should be adequate for most substrates (since most substrates are only ~500 microns thick or less). Larger values may be needed in some cases.
D	Example: 100 (mm)	This is the **depth** of your array of cuts. It is NOT the depth of your cut. That will be programmed later. Basically, this 'D' parameter is equivalent to the total amount of Y-axis distance that you expect to cover after you are finished with ALL of your cuts. If you are going to dice an entire wafer, for example, then you will likely program this value to be the same as your cut width (**'W'**). As with the cut width, make this value about 10 mm larger than what you expect, in order to compensate for any error in centering your wafer on the mounting tape. So if you were dicing a 100 mm wafer completely from top to bottom, then you should set this parameter to '110' (mm).
θ **Rotation Index**	Example: 90	This is the angle that the chuck will rotate when you press the rotation **INDEX** button followed by pressing a rotation **direction** button, which is either **Clockwise** or **Counter-Clockwise**.
Spindle Rotation	Example: 25000 r.p.m.	This is the spindle rotation speed used during the cutting. The default (most common) setting is 25000 r.p.m. See appendix for more information.

Step	1 through 30	This is the step number within the dicing program that you are running. You can program up to 30 steps, which will all run sequentially, with one cut made per step. If you program 3 steps, for example, and program a total of 5 cut lines, then the program will run through the steps until all cuts have been completed, in this example, running through steps 1, 2, 3, 1, 2 (since there are 5 cuts). Most users will only need to program step number 1 of the program.
Blade Height	Example: 0.060	This is the **height** of the blade (above the chuck) as your wafer is being diced. In the example shown, a value of '0.060' (60 microns) would cut into the blue tape about 15 microns deep (since the blue tape is ~75 microns thick). If UV tape is being used (~120 microns thick), then a higher value could be used for the blade height, such as '0.090' mm (90 microns).
Depth Steps	Example: 0.025 Set this value to '0' when not being used.	This parameter can be used if you want to make several passes at increasing depths for each cut. Users that wish to cut into thick substrates and/or that want a cleaner kerf could make use of this parameter. In the example shown, a value of '0.025' (25 microns) would cause the blade to pass over your desired cut line starting at the blade height programmed in '**H**' (see above), and then pass over it again 25 microns lower, repeating this cycle until it reaches down to your **Blade Height** parameter. For example, if you had programmed '**H**' as 2.000 mm, and had a **Blade Height** of 0.060 mm, and a **Depth Step** of 0.025 mm, then it would cut over each cut line at a height of 2.000, then 1.975, then 1.950…until the blade height reached a value of 0.060 mm.
Index	Example: 10 (mm)	This is the Y-axis spacing or 'pitch' between cut lines, also known as the Y-index. After making cuts along one axis of your wafer, you can change this value after you rotate the chuck 90 degrees, to achieve whatever final die size that you want.

Cut Speed	Example: 5 (mm/sec)	This is the horizontal speed that the substrate will travel at during dicing. See the appendix at the end of this SOP to select a proper cut speed for your particular dicing application.
Total Lines	Example: 10	This is the total number of cut lines that you want to cut prior to you changing the ***θ*-Rotation** angle (if applicable). You should set this value to '1' if you want to perform a test cut prior to dicing an array of cuts. Performing a test cut is important to ensure proper microscope/blade alignment. If you are editing a previously unused ("EMPTY") cut program, then you may notice that the word "NO" appears in this parameter field. You can use the **SHIFT** button to change this from "NO" to "1", and then press the **ENTER** button to save that change. Now you can change the value from a "1" to some other number if desired.

When you are finished programming your parameters, press the **ESC** button to return to the **Cut Entry** screen. Then press the **ESC** button one more time to return to the main menu.

h. **<u>Loading a Sample</u>:** Move the Y-axis all the way back to get the spindle as far away from you as possible. Press and hold the Y-axis **Hi-SPD** button while also pressing and holding the **up arrow** button (see image below).



As you hold both of these buttons down you should notice the spindle and microscope move backward. Once the spindle is all the way back to the Y-axis upper limit you will hear an alarm beep. You will also notice an alarm displayed on the bottom left of the computer monitor which says:
"**Y: REAR LIMIT END**". This is normal. Press the **ESC** button to acknowledge and silence the alarm.

Move the control panel to the right by grabbing both sides of the metal housing and pushing it to the right using your left hand. You may also have to slide the right safety cover over to the right so it is flush with the control panel. (see image below)



Move the X-axis all the way to the right so you have maximal clearance for sample loading. Press and hold the X-axis **Hi-SPD** button while also pressing and holding the **right arrow** button (see image below). Once the chuck is all the way to the right you will hear an alarm beep. You will also notice an alarm displayed on the bottom of the computer monitor which says: **"X: RIGHT LIMIT END"**. This is normal. Press the **ESC** button to acknowledge and silence the alarm.



Make sure that the chuck vacuum is off. The red light on the **VAC** button should be off. If the red light is on, press the **VAC** button once to turn it off.



If there is a previously diced sample already on the chuck, and you want to remove it, then you can remove it now. The sample that you load needs to be mounted on dicing tape in a mounting frame. **Once your sample is mounted you can place it on the chuck.** Make sure the metal mounting frame is in the correct position, aligned to the magnets on the outside area of the chuck. Then you can perform a gross sample alignment by simply grabbing and rotating the chuck until your sample is roughly aligned to the X-axis. You will be doing a fine alignment procedure later.

Move the control panel back to its original position by grabbing both sides of the metal housing and pushing it to the left using your right hand. Press the **VAC** button once to turn on the chuck vacuum. The red light on the **VAC** button should turn on. If you hear an alarm ("Chuck Vacuum Low"), press the **ESC** button to acknowledge it. You should also see the vacuum gauge change so that the white needle now points somewhere in the blue region (see image below).



i. **<u>Blade Height Zeroing Setup</u>:** Please note that this step only needs to be performed one time and you **do not** have to repeat this step before dicing another wafer. If you have already performed this step once before, you can proceed to step **'j'**. If you have not performed a setup yet, then turn on the **SET UP** function by pressing the **ON** button (see image on next page).



You should see the **Set Up** screen appear which shows a few different setup parameters. These parameters are important for the system to know whether or not a blade has been changed, how many cuts have been made since the last blade change, how much blade exposure there is, and also where the chuck is with respect to the Z-axis coordinates. Since the sample chuck surface should be equivalent to a Z-Height of 0, the system needs to calibrate this positioning by having the blade slowly approach the chuck until it makes contact.

Setup the following parameters as follows, and be sure to press the **ENTER** button after entering any new values. Use the **SHIFT** button on the keypad to toggle the **Blade Change** or **Manual Assist** parameters if needed.

Parameter Name	**Parameter Value (Description)**
Blade Change	NO
Manual Assist	NO
Blade Exposure Limit	1.1000 (mm)
Set Up Compare Limit	0.100 (mm)
Current Blade Exposure	This value will vary depending on the type of blade installed, how many cuts it has made, etc. This value should be determined by the appropriate MNC staff personnel and should NOT be changed by the user.

Note the location of the **Z-EM** stop button, but **do not press it at this time.**
(see image below)



The last step of this setup procedure will cause the Z-axis to automatically move down (very slowly) until the blade makes contact with the chuck. Whenever you are ready, finish the setup procedure by pressing the SET UP function **ON** button one more time. As the blade is approaching the chuck, you should see a message on the Set Up screen (just above the rectangle) that says: **WORKING !!** It takes around 3 minutes for the Z-axis to move down until the blade makes contact with the chuck, so please be patient. Be prepared to press the **Z-EM** stop button if you happen to see any sparks or irregular behavior as the blade is making contact with the chuck.

Once the setup procedure is complete, you should see the chuck move to the right, centered under the microscope. The computer will automatically exit out of the **Set Up** screen and return to the main menu. Proceed to the next step **'j'**.

If the setup doesn't complete successfully and you get an error that says: **"SETUP COMPEARE"**, press the **ESC** button once to silence the alarm. The error may have resulted from the **Blade Correct Quantity** being a negative value, which can happen because the surface of the chuck isn't perfectly flat.

If the **Blade Correct Quantity** is a negative value (either the value shown on the left or the one shown in brackets [ ] on the right), then move the cursor to the **Blade Change** parameter and press the **SHIFT** button on the keypad to toggle the parameter to **YES**. Then press the **ENTER** button.

Move the cursor to the **Current Blade Exposure** parameter and type in whatever value is currently being displayed there (if the value is greater than 1.30, then just enter a value of 1.30). Then press the **ENTER** button.

Re-run the **SET UP** function by pressing the **ON** button again. Remember that it takes around 3 minutes for the Z-axis to move down until the blade makes contact with the chuck, so please be patient. Be prepared to press the **Z-EM** stop button if you happen to see any sparks or irregular behavior as the blade is making contact with the chuck.

If the setup has now completed successfully, then proceed to the next step **'j'**. If the second attempt to run the setup fails, OR if the **Blade Correct Quantity** was not a negative value and you got an error anyway, then please report a problem on Badger and shutdown the tool as per step '**s**' of this SOP.

j. **Focusing Sample Under Microscope:** Press the **DISP** button to change the display on the computer monitor. It should now show the microscope display. You may not be able to see any features on your wafer yet, especially if the camera is out of focus, or if your sample is not positioned under the microscope. You may also have to adjust the microscope lamp brightness by rotating the **"Direct Lighting"** knob which is located just below the monitor.

Move the Y-axis using the **up or down arrow** buttons or the X-axis **left and right arrow** buttons if needed until you see the microscope lamp shining on a feature or the bottom edge of your sample.

If needed, press and hold the X-axis or Y-axis **Hi-SPD** button while also pressing the X-axis or Y-axis **arrow** buttons to make those axes move faster.

To focus the optics on the surface of your sample, unlock the **coarse focus knob** by turning the lock-lever counter-clockwise until it is loose. Then turn the coarse focus knob to focus your sample. Re-lock the **coarse focus knob** by turning the lock-lever clockwise until it is lightly snug.
See image below for coarse focus knob and lock-lever locations.



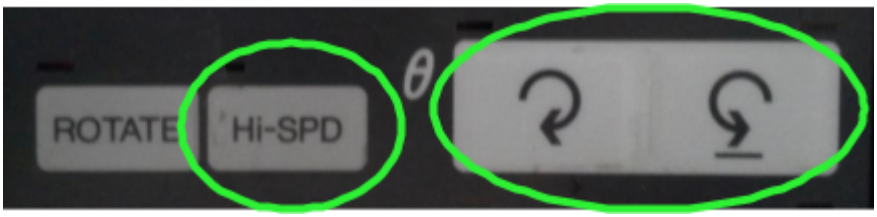
Use the fine focus knob to make any other focus adjustments to optimize the focus on your feature of interest. To do this, unlock the **fine focus knob** by turning the **lock-lever** counter-clockwise until it is loose. Then turn the **fine focus knob** to finish focusing your sample. Re-lock the **fine focus knob** by turning the **lock-lever** clockwise until it is lightly snug.
See image below for fine focus knob and lock-lever locations.



k. **Sample Alignment:** Look in the microscope eyepiece and you should see a set of perpendicular crosshair lines. The sample or feature of interest will have to be aligned to the horizontal crosshair line. You should also see one or three horizontal hairlines on the computer monitor.

Jog your sample up or down on the computer monitor using the Y-axis **up or down arrow** buttons until it is vertically centered on the monitor or over the microscope's horizontal crosshair. Now it is time to align your sample to the hairlines by making adjustments to your ***θ*-Rotation** angle.

To adjust the ***θ*-Rotation** angle, press (or hold if necessary) the **Clockwise or Counter-Clockwise** rotation buttons. If you want to make faster ***θ*-Rotation** angle adjustments, you can press and hold the **Hi-SPD** button while also pressing the **Clockwise or Counter-Clockwise** rotation buttons (see image below).



You may notice that your feature of interest begins to move up or down on the computer monitor as you rotate the ***θ*–Rotation** angle. To compensate for this, use the Y-axis **up or down arrow** buttons to periodically re-center the feature of interest within the hairlines. Once your feature appears to be roughly aligned on the hairlines, you will need to check the fine alignment by moving your sample to the left and to the right and seeing if it appears to move up or down with respect to the hairlines.

Toggle between the X-axis **left and right arrow** buttons and watch your feature with respect to the hairlines. Adjust your ***θ*–Rotation** angle by a small amount (tapping the **Clockwise or Counter-Clockwise** rotation buttons) to improve your alignment as needed. Continue to check the alignment using the X-axis **left and right arrow** buttons. Also continue to adjust the Y-axis position using the **up or down arrow** buttons as needed to keep your feature centered on the hairlines. As your alignment gets better you may need to press and hold the X-axis **Hi-SPD** button while also pressing /toggling the **left or right arrow** buttons, in order to notice if any small alignment adjustments are needed.

Once you are satisfied with the sample alignment, move the Y-axis until the microscope and hairlines are centered over a region where you can perform a test cut.

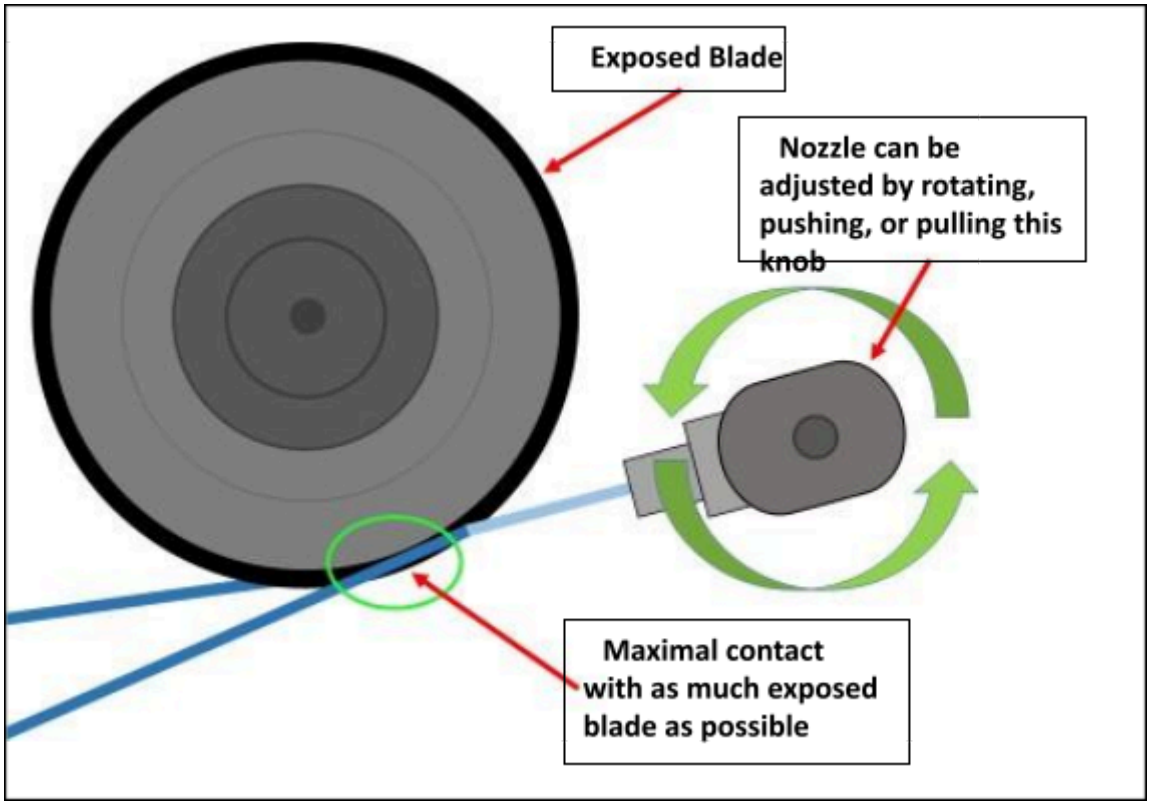
To ensure that there is no backlash, press the Y-axis **down arrow** button once and then press the **up arrow** button once. Next, press the ***θ*–Rotation Clockwise** button once and then press the **Counter-Clockwise** button once. Now the backlash should be resolved. You must perform this backlash compensation anytime you move either of these axes, prior to any cutting.

l. **Water Nozzle Adjustment:** The water nozzle located on the right side of the dicing blade needs to be positioned properly such that two conditions are met:

1) The stream of water is split into two streams from its interaction with the blade

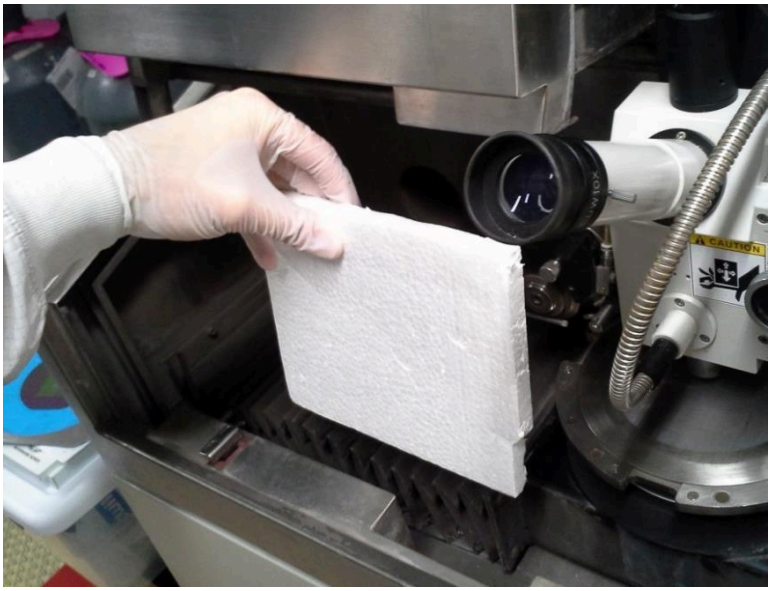
2) The stream of water is directed toward the blade at an angle such that it maximizes contact with the exposed portion of the blade

(see image below)



In the image above, you can see that the incoming stream of water (light blue line) is splitting into two streams (dark blue lines) based on how it deflects around the blade. You can also see how an appropriate angle setting for the water nozzle results in the split stream making contact with as much exposed blade area as possible. If the stream is aimed too high, water is diverted toward the flange (gray region holding the blade on the spindle) rather than the blade itself, which can lead to premature blade failure.

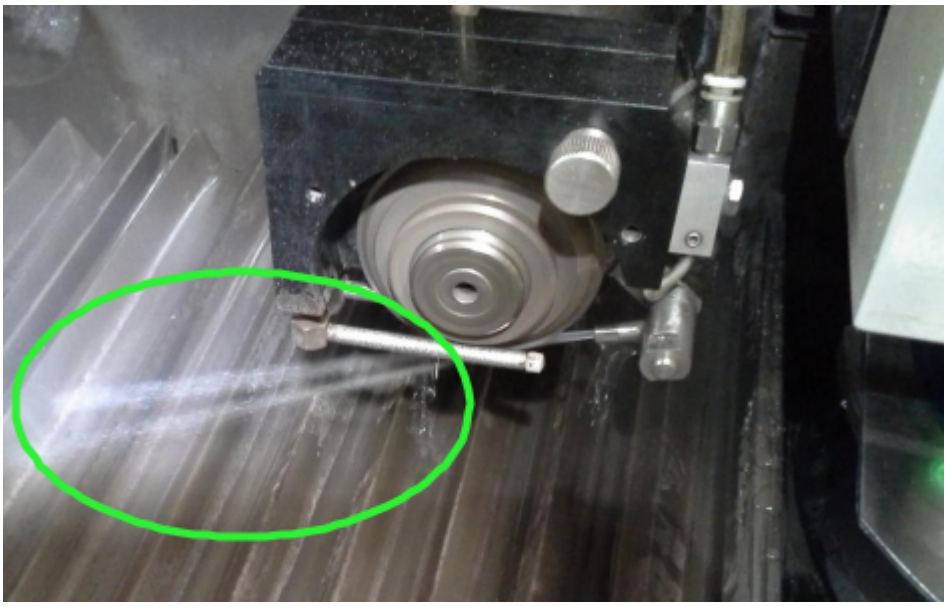
The only way to check if these two conditions have been met is to turn on the cut water and adjust the nozzle position as needed. You will want to hold a piece of Styrofoam between you and the spindle (using your left hand) to serve as a splash shield (see image below).



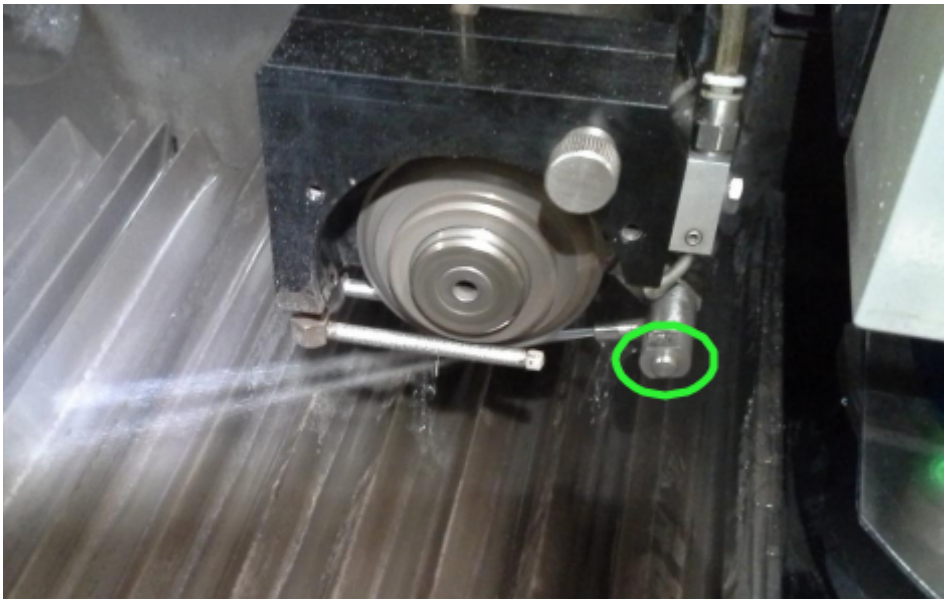
While holding up the piece of Styrofoam with your left hand, use your right hand to turn on the cut water by pressing the **Cut Water** button (see image below).



Once the cut water is on, move your Styrofoam splash shield as needed in order to keep as much water in the machine as you can. If the water nozzle located on the right side of the dicing blade is in the proper position, you should see the water stream split into two streams (see image on next page).



If the stream doesn't appear to split as shown in the image above then the water nozzle position will need to be adjusted. If this is needed, then you will need to grab the water nozzle at the following location (see image below).



With your right hand, CAREFULLY grab the water nozzle by pinching it with your thumb and index finger and then pull or push the nozzle gently as needed. You may have to rotate the nozzle as well if it's not hitting the blade at the proper angle. Adjust the nozzle position as needed to satisfy both conditions as listed on page 16. Once this is set properly, press the **Cut Water** button to turn off the cut water.

m. **Secure Left Safety Cover:** Turn **OFF** the spindle rotation by pressing the **SPNDL** button (see image below):



Once the spindle is off you should hear a loud click. This is a safety solenoid that will secure the left safety cover during dicing. Now that the safety solenoid is open and unlocked, close the left safety cover all the way by lifting up the black handle, pulling toward you, and then pushing the black handle down firmly.

While holding the safety cover closed, turn **ON** the spindle again by pressing the **SPNDL** button as per the image above. You should hear a loud click again. The safety solenoid should now have locked the left safety cover so that it can't be opened until the spindle is shut off again.

n. **Performing a Test Cut:** If you have already performed a test cut on another sample, proceed to step **'q'**. If you have not yet performed a test cut then press the **DISP** button as needed to toggle the display back to the main menu. On the keypad, press the number '**2'**, to enter the **Cut Entry** screen from the main menu.

Under the left column of cut entries you will see a data entry field titled:

>> **PROGRAM No. [____]**

The cursor should already be in the data entry field box, but if it isn't, you can use the arrow keys to move the cursor. Type in the number of the cut program that you want to run (for example 1, 2, 3, etc.). Once you've entered the desired cut program number, press the **ENTER** button to access that cut program. Ensure that all of your parameters are correct prior to running the dicing program. **For your test cut**, you should program the **Total Lines** parameter to be '1' so that the dicing stops automatically after one cut has been completed. Then you won't have to worry about having to abort or stop the cutting program after it has begun.

Place the piece of Styrofoam between the left safety cover and the control panel so that it fits behind the lip on the front of the system (see image below).



Press the **FULL** button to prepare the system for running a fully automatic program.

Next, press the **START/STOP** button to run the dicing program. You should see the cut water turn on indicated by the red light on the **Cut Water** button. See image below for **FULL** and **START/STOP** button locations.



Once the cut program is finished, you should see the chuck move to the right, centered under the microscope, with the microscope lamp on.

Press the **FULL** button to disable it (the red light should turn off).

Press the **Cut Water** button to turn the cut water off. Press the **DISP** button if needed to toggle the display to the microscope, so you can see your cut. Remove the piece of Styrofoam and blow off any water on your sample using the nitrogen gun.

o. **Microscope Alignment & Hairline Adjustment:** If the cut appears to be off center from your hairlines, then you can adjust the vertical position of the cut on the monitor display by making an adjustment on the **microscope alignment knob**.

Unlock the **lock-lever** for the **microscope alignment knob** by turning it counter-clockwise until it is loose. Turn the **microscope alignment knob** such that the cut is vertically centered on the horizontal crosshair in the microscope. Re-lock the **microscope alignment knob** by turning the **lock-lever** clockwise until it is lightly snug. See image below.



Most users will want the hairlines centered vertically on the monitor so that they coincide with the horizontal crosshair line in the microscope eyepiece.

If you want to change the vertical location of these hairlines at any time, you need to first ensure that the **F1** button is **disabled** (located on the upper left of the control panel). The red light above the button should be off. If it is not off, turn it off by pressing the **F1** button once. Now you can press and hold the **SHIFT** button on the keypad while also pressing the **up or down arrow** buttons on the keypad and you will see the vertical location of the hairlines change accordingly.

If you want to adjust the vertical spacing between the upper and lower hairlines, you need to make sure that the **F1** button is **enabled**. If the red light on the **F1** button is not on, press the **F1** button once to enable it. Next, press and hold the **SHIFT** button on the keypad while also pressing the **up or down arrow** buttons on the keypad and you will see the vertical spacing between the hairlines change accordingly.

These hairline adjustments will come in handy after you perform a test cut to verify your cutting location, kerf width, or other feature measurements that you may want to perform.

p. **Using the Measurement Function:** If you want to measure the kerf width of a cut, or the distance between two features (for example), there is a measurement function that you can enable for this capability. Once you are in the location that you want to start measuring from, press the **MEAS** button to enable the measurement function (located next to the **DISP** button). The micrometer for both the X and Y-axes should appear toward the bottom of the screen. The units are shown on the left. If you need to toggle the units between inches (inch) or millimeters (mm), then press the **SHIFT** button on the keypad. Then press the Y-axis **up or down arrow** buttons or the X-axis **left or right arrow** buttons to move to your final measurement location. You will notice the measured displacement value change for each axis that you move along. When you are finished with this function, press the **MEAS** button to disable it.

q. **Performing An Array of Cuts:** Change your **Total Lines** parameter if needed in your program, if you plan on doing more than one cut. Press the **DISP** button if needed to toggle the display to the **Cut Program** screen if you need to edit any parameters. Then press the **DISP** button if needed to toggle the display back to the microscope. Jog the Y-axis **up or down arrow** buttons to move toward your cut program's first cut line location.

If desired, you can press the Y-axis **INDEX** button to enable the indexing option and then use the Y-axis **up or down arrow** buttons to confirm that the **Index** parameter and the **Total Lines** parameter in your program are accurate. When you are finished with this indexing option, return back to your first cut line location and then disable the **Index** button by pressing it once.

To ensure that there is no backlash, press the Y-axis **down arrow** button once and then press the **up arrow** button once.

Place the piece of Styrofoam back in between the left safety cover and the control panel so that it fits behind the lip on the front of the system.

Just as you did with the test cut, press the **FULL** button to prepare the system for running a fully automatic program. Next, press the **START/STOP** button to run the dicing program. You should see the cut water turn on indicated by the red light on the **Cut Water** button.

Once the cut program is finished, you should see the chuck move to the right, centered under the microscope, with the microscope lamp on.

If you need to abort the cut program for any reason, press the **START/STOP** button, and then you should see the light above this button begin to blink. Once it finishes the current cut, it will abort the program.

Press the **FULL** button to disable it (the red light should turn off). Press the **Cut Water** button to turn the cut water off. Press the **DISP** button if needed to toggle the display to the microscope, so you can see your cut if needed. Remove the piece of Styrofoam and blow off any water on your sample using the nitrogen gun.

If you want to dice the wafer in another orientation, for example, after rotating 90 degrees, you can do that now. Press the **ROTATE** button to select the index option for ***θ*** – **Rotation**. Next, press the **Clockwise** rotation button once to rotate the chuck 90 degrees.

You may get an error when trying to rotate 90 degrees in a particular direction. This error may appear as "CW-END OVER" or "CCW-END OVER". This can happen if the chuck has been rotated too far in one direction. If this happens, press the **ESC** button to silence the alarm. Rotate the chuck in the opposite direction, so you don't get the same error.

Press the **ROTATE** button to disable it once you are done rotating.

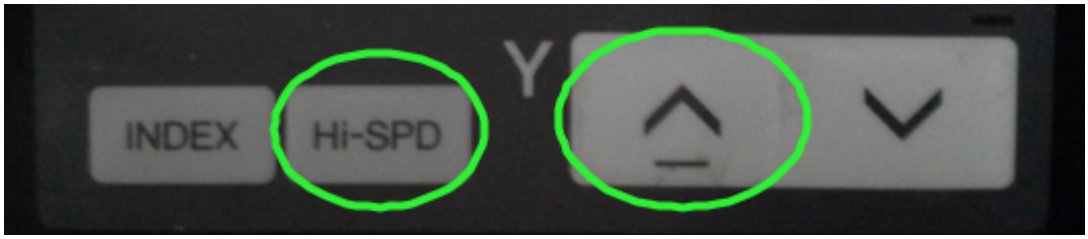
To eliminate any possible backlash, press the ***θ*** – **Rotation Clockwise** button once and then press the **Counter-Clockwise** button once. Now the backlash should be resolved.

If you are going to use the exact same parameters while in this orientation, then you can simply go back to the beginning of this step '**q**' and repeat the instructions as needed.

If you want to cut new samples, go back to step **'h'** on **page 8** of this SOP and continue from that point forward. **<u>You can skip</u>** step '**i**' however (this is the setup step for the blade zeroing) because you only needed to perform this setup one time before dicing your very first substrate.

If you are finished dicing, then proceed to the next step for instructions on sample unloading and shutting down the system.

r. **<u>Sample Unloading</u>:** Move the Y-axis all the way back to get the spindle as far away from you as possible. Press and hold the Y-axis **Hi-SPD** button while also pressing and holding the Y-axis **up arrow** button (<u>see image below</u>).

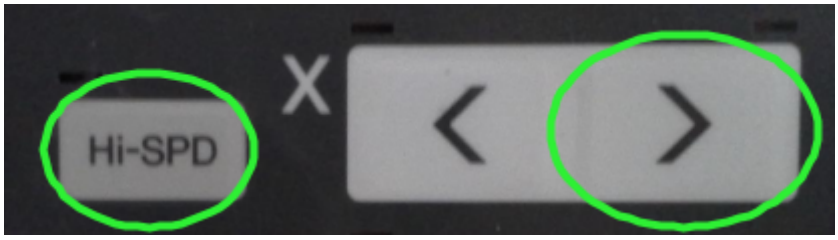


As you hold both of these buttons down you should notice the spindle and microscope move backward. Once the spindle is all the way back to the Y-axis upper limit you will hear an alarm beep. You will also notice an alarm displayed on the bottom left of the computer monitor which says:
"**Y: REAR LIMIT END**". This is normal. Press the **ESC** button to acknowledge and silence the alarm.

Move the control panel to the right by grabbing both sides of the metal housing and pushing it to the right using your left hand. You may also have to slide the right safety cover over to the right so it is flush with the control panel. (see image below)



Move the X-axis all the way to the right so you have maximal clearance for sample unloading. Press and hold the X-axis **Hi-SPD** button while also pressing and holding the **right arrow** button (see image below). Once the chuck is all the way to the right you will hear an alarm beep. You will also notice an alarm displayed on the bottom of the computer monitor which says:
"X: RIGHT LIMIT END". This is normal. Press the **ESC** button to acknowledge and silence the alarm.



Turn off the chuck vacuum by pressing the **VAC** button. The red light on the **VAC** button should turn off (see image below).



Remove your sample from the chuck.

Move the control panel back to its original position by grabbing both sides of the metal housing and pushing it to the left using your right hand.

s. **Shutting Down the System:** To shut down the system, press the **SPNDL** button to turn off the spindle rotation. When you hear a loud click, the safety solenoid should have unlocked so you can open the left safety cover to let the system dry out. Press the **DISP** button if needed to toggle to the **Cut Program** screen.

   Press the **ESC** button to exit the **Cut Program** screen. Press the **ESC** button again to exit the **Cut Entry** screen and return to the main menu.

   Turn the keyswitch from the **ON** position to the **OFF** position.

t. **System Disable:** Disable the "saw-disco 552" in Badger.

7 Appendix

a. **Spindle Rotation Speed:** Most users are going to use a spindle speed of 25000 r.p.m. since that is adequate for most users' needs. If you want to use a spindle rotation speed other than 25000 r.p.m., you should discuss this with the MNC process person that is assigned to this tool.

b. **Cut Speed:** Some forms of quartz and sapphire can cause more blade wear and may need to be cut very slowly in order to maintain enough blade exposure during your dicing job. On the other hand, sometimes cutting a hard material too slowly can cause the blade to become loaded and not self-sharpen properly which may result in blade failure during dicing.

   Monitor your cut depths and the dicing blade integrity after you are finished dicing and if you notice incomplete cuts, a broken blade, or a blade with a very small blade exposure remaining, report a problem in Badger stating that the blade needs to be replaced. Then you should notify the MNC process person that is assigned to this tool so they can give a recommendation for slower/faster cut speeds, the use of depth steps in your program, specialty blades to use or request, etc.

See the tables listed below for recommended maximum **Cut Speed** values and to see the estimated kerf width produced from each type of blade.

Substrate	**Recommended Maximum Cut Speed**
Silicon	5.0 mm/sec
Glass / Pyrex	2.0 mm/sec
Quartz / Sapphire	0.5 mm/sec

Blade Type	**Kerf Width**	**Substrates Allowed**
Silicon Dicing Blade	~50 microns, tested with **Cut Speed** of 2-10 mm/sec.	Silicon Only
"Everything" Dicing Blade	~170-200+ microns, depending on substrate and **Cut Speed**.	Silicon, Glass, Quartz, Sapphire, etc.