K&S 377 Wafer Saw ("wafersaw")
Operating Procedures

Contents:

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1. SYSTEM OVERVIEW:

The K&S 377 wafer dicing rotary saw is normally used to score into crystalline substrate which can then be easily snapped along the dicing lines. The wafer is held by a vacuum chuck which is rotated to align the dicing line to the direction of the cutting blade. A video microscope allows precision alignment and cut placement.

1.1 Process: The wafersaw was designed for dicing finished devices in a production environment. As such, the system is inherently "dirty" -- the saw blade generates grit, as it cuts the substrate, which is spread all over the rest of the substrate by ordinary city water used to cool the cutting blade. In a production environment, devices are protected from damage by a passivation layer. However, if your substrates contain delicate surface structures or need to be protected from surface damage, then you should coat your wafers with a protective film before dicing (such as photoresist.) If this is not an option, consider manual dicing (contact staff about this.)

1.2 Substrates For safety and environmental reasons, cutting GaAs or InP substrates is strictly prohibited (they shatter anyway). Silicon, glass, and silicon/glass bonded substrates up to 6" may be diced. Quartz (fused silica), sapphire and lithium niobate are very hard substrates and require special blades and settings. Consult staff before cutting substrates other than those allowed and listed here. For more details about specific substrate processing issues, consult section 9.

Because of the vacuum chuck, the smallest substrate size that can be cut on this system is 2". Smaller substrates and pieces can be cut if they are firmly mounted on a larger substrate. Double stick tape or crystal-bond may be used for mounting pieces.

It is highly recommended that blue dicing tape be used for all substrates. This provides additional protection for the wafer chuck as well as added insurance against die getting lost or damaged.

1.3 Materials Allowed: No GaAs processing is allowed at this sytem (as above).

1.4 Facilities: The facilities required for this system are:

CDA: Pressurized clean dry air supports the air bearings for the saw spindle and supplies the venturi pump which provides vacuum for the chuck.

Nitrogen: Supplies the air gun.

Water: Industrial and lab DI water supplies cooling to the blade as it is cutting and the red hand sprayer, located on the left side of the tray.

1.5 Equipment Description: The rotary saw blade is mounted on the spindle, which can be positioned up/down (z-axis) and forward/backward (y-axis) relative to the vacuum wafer chuck. The entire tray table/wafer chuck assembly moves from side-to-side (x-axis) to facilitate cutting. The actual cutting takes place from right to left. The wafer chuck rotates (theta-axis) to allow alignment of the wafer to the saw blade.

There are four different alignment procedures which must be performed, in the order described, before wafer cutting:

Alignment #1: Height calibration - This procedure allows the machine to determine z=0, where the blade edge meets the top of the wafer chuck. The spindle must be "on" (the saw blade is spinning). The spindle is aligned to the center of the wafer chuck and very slowly lowered onto it. Where it makes electrical contact is z=0. This procedure must be done first, before other commands are used.

Alignment #2: Microscope focus - In order to properly view your substrate, the microscope focus may need to be adjusted. This will need to be adjusted when your substrate is in place and readjusted for substrates of different thickness.

Alignment #3: Street alignment - This procedure allows you to rotate the chuck so that the "street" on the wafer that you would like to cut is parallel to the direction of the saw.

Alignment #4: Y-offset - This procedure aligns the actual position of the blade to a crosshair on the video display. This then allows you to use the crosshair to accurately position the blade cut.

2. SAFETY

2.1 Chemical Hazards: Silicon dust presents a respiratory hazard. Make sure to wear gloves at all times and change them often, to prevent spreading of silicon dust. Avoid breathing dust by keeping work surfaces wetted down while processing. Some users choose to wear a dust mask; this is not required, but provides appropriate, additional protection.

2.2 Equipment Hazards: Keep away from moving parts. Stand back from the machine while it is operating. Wear safety goggles whenever operating this system.

3. QUALIFICATION CHECKLIST

- Describe the facilities used at the wafersaw.
- Describe the acceptable materials which can be used at the wafersaw.
- Demonstrate how to prepare and measure a standard wafer for dicing.
- Describe the different blades and reasons for using them.
- Identify and describe the four calibration procedures required for cutting the first wafer.
- Identify which of these calibrations are required for subsequent wafers (of the same type as the first.)
- Describe the function of each of the process parameters.

4. OPERATION
There are two input panels on this system. The power switches and stage controls are located on the left panel. In these operating procedures, commands enclosed in angle brackets ("**<button name>**") indicate controls on this left panel. The Programming Keyboard is located on the right control panel. Commands enclosed by square brackets ("***panel section* [button name]**") indicate the controls on this right panel.

4.1 Preparation

4.1.1 Prepare substrates.
- The surface of your substrate should be protected, if it will be damaged by high pressure water and silicon grit.
- If you have a standard-sized substrate and plan to leave 100 microns or so of silicon, blue dicing tape should be mounted on the backside of the substrate. Roll the tape on, smoothing out any air bubbles which may prevent the substrate from sitting perfectly flat on the chuck.
- If your substrate is smaller than 2", it should be mounted on a larger, solid dummy wafer so that the vacuum chuck can hold it down. Do not use a larger piece of blue dicing tape (the vacuum chuck will cause the tape to wrinkle, preventing the substrate from sitting flat on the chuck.) Heavy duty double-stick tape or crystal bond may be used for mounting your substrate onto a carrier/dummy wafer. (Do not use ordinary office tape: it will absorb water, swell, and come off.)
- If you plan to cut all the way through a substrate, it should be mounted on another substrate. (This will prevent accidental cutting into the vacuum chuck, which will damage the chuck, the blade, and your substrate.) Double-stick tape or crystal bond may be used.

4.1.2 Measure sample thickness.
It is absolutely important to measure the thickness of your sample stack. Mistakes can lead to permanent damage to the system, as well as your sample. Use the digital caliper to measure the thickness of your entire sample stack (substrate, with dicing tape and dummy wafer.) Before using the caliper, make sure the units are appropriate (mm versus inches). Also, make sure the caliper is zeroed. The thickness measurement will be entered on the Parameter screen (section 4.3.7.)

4.1.3 Identify the lines you wish to cut.
You should be able to locate your landmarks under the microscope.

4.1.4 Select a blade
(correct for the material you are sawing and the depth of cut you need.) See section 9.2 for guidelines on blade selection.

4.2 Equipment Setup:
You should find the wafersaw clean and in the Standby condition, as described in section 4.6.

4.3 Startup

4.3.1 Enable the wafersaw on Coral
- Note any Coral problem reports before starting.
- The Coral indicator LED is mounted on top of the monitor.
- Put on gloves (latex or vinyl).

4.3.2 Change the blade
- It is recommended that you obtain your own blade. For details on how to select the right blade for your wafer, see section 9.
- For safety, make sure **<Emergency Stop>** and **<Stop>** buttons are lit.
- Remove the black plastic blade guard, which is held in place by a screw mount on the right.
- A spindle ring nut and a hub hold the blade in place. The blade tool should be used for screwing and unscrewing the ring nut. To use the blade tool, place the hex key in the hex-shaped hole in

the center of the spindle. Match the two pins on the knurled knob to the two holes on the spindle nut. Hold the T-handle to keep the spindle from turning. Turn the knurled knob <u>counter-clockwise</u> to loosen the spindle nut. Once loosened, you can remove the blade tool and use your fingers to remove the nut.

- When the blade tool is not in use, store it on top of the monitor in the shallow depression (so it will not roll off.)
- When handling the blade, use your fingertips to hold the inner rim of the blade. (Do not hold the blade; it is fragile and will break easily.)
- The blade should come off and mount on the spindle easily. It may require a little wiggling, but should not be forced. If the blade is difficult to remove or replace, call maintenance, as the spindle may be damaged and further use may damage it irreparably.
- When mounting a new blade, use a cleanwipe and wipe the spindle and the inner ring of the new blade to remove any grit or residue. This will protect the spindle from wear. Check your new blade for dings and cracks; any defects may result in damage to your sample.
- When replacing the ring nut using the blade tool, tighten only wrist-tight. It will tighten itself further during use.
- Replace the black plastic blade guard, and tighten down the screw mount to the right.

4.3.3 Start the utilities

- **Switch the Monitor power ON**. The monitor screen will display the following:

```
                    UTILITY STATUS
     - - - - - - - - - - - - - - - - - - - - - - - - -
         AIR PRESSURE        .   .   .   .       LOW
          POWER          .   .   .   .   .   .        OFF
         WATER PRESSURE .   .   .              LOW
          "STOP"  SWITCH      .   .   .   .   .    ON
          SPINDLE      .   .   .   .   .   .   .       OK
          CONTACT/CHUCK .   .   .   .          OK
```

- **Turn ON the CDA (Clean Dry Air) supply**:   Turn the green CDA valve (at the right rear of the machine) ¼ turn counterclockwise. Make sure the CDA valve is all the way ON, or machine fault will occur. It should be about 4.5 CFM. The CDA the air bearing which supports the spindle and also supplies the slight back purge on the chuck when vacuum is off.
- **Turn ON vacuum pump:** Turn the black handle on the lower right front of the machine base to the ON position. This manual valve providing CDA to the venturi pump.
- **Press <Emergency Stop>** (the button light will go off) When this button is lit, the system is in the emergency stop mode; this will turn off all motors, cutting & cooling water flow, and the microscope light, however the parameter values and calibration are retained.
- **Press <Stop>** (the button light will go off & all options on the monitor should indicate "OK") The 30 second timer at the lower right corner of the monitor will start to countdown. After the countdown timer reaches 0, the red display above the flat touch-pad buttons will change from "NO POWER" to "K&S 775".   If abnormal startup conditions are encountered, notify maintenance.

4.3.4. Start the SPINDLE motor
- Check the Parameters page. Make sure the spindle speed is appropriate for your application and needs.
- **Press *mode* [spindle]** and wait about 30 seconds until it comes up to speed.

4.3.5. Calibrate HEIGHT
- **Select *routine* [unload]**. If not there already, this moves the chuck to the unload position and turns off the chuck vacuum.
- IMPORTANT: The chuck surface must be bare, and clean and dry, otherwise the height calibration will be incorrect.
- **Press *routine* [height]**. The chuck will move under the microscope light.
    - Sometimes, the system will beep and the error message "Spindle not up to speed" will appear. Try pressing *mode* **[spindle]** off and then on. Wait 30 seconds, then try *routine* **[height]** again.
- **Use the <x> and <y> dials** to center the microscope light on the chuck. (The red **<fast>** button will increase the travel speed of the **<x>** and **<y>** dials.)
- **Select <enter>**. The saw blade will move over the center of the chuck, and slowly drop down. When the blade makes electrical contact with chuck, the z-axis is set to zero.
    - On occasion, when the system has lost memory (such as following a system reboot), the height calibration routine can take several minutes to execute.
    - If, instead, nothing appears to be happening (i.e., the z-axis worm gear motor is not rotating at all), then try pressing **<enter>** again. (Sometimes the **<enter>** button is sticky.)
    - If contact is faulty, the routine stops, and the "UTILITY STATUS" info will appear on the monitor, ie. – CONTACT/CHUCK ……. BAD. If this occurs, contact maintenance.
- When done, the blade will lift and the chuck will move to the "unload" position.

4.3.6 Program PARAMETERS
The monitor screen should display something similar to the following:

Parameter Screen   (typical)

PROGRAM # NONE		(MILLIMETER)
DIAMETER	150	DIAMETER toggles with X LENGTH / Y WIDTH (see section 9)
X LENGTH	N/A	
Y WIDTH	N/A	
INDEX I	10.0	
INDEX II	10.0	
DEPTH	N/A	DEPTH toggles with CUT DEPTH. **Use of CUT DEPTH** is recommended. See section 9.
CUT DEPTH	.457	
THICKNESS	.625	
EXPOSURE	.762	"EXPOSURE" see section 9 and cut diagram (this section.)
FEED RATE	5.0	FEED RATE and ENTRY SPEED are programmed by the same "FEED RATE" key, which toggles between the two.
ENTRY SPEED	5.0	
SPINDLE SPEED	10.0	
CLEAN WAFER	OFF	

- To change individual parameters,
  - select *parameters* [change]
  - select *parameters* [item] for the item to be changed
  - enter [value] using the numeric keys
  - select *parameters* [enter].
  - *parameters* [CE] button will delete incorrect entries, if used before the *parameters* [enter] button.
  - Warning: the keypad can be touchy. If parameters entered are outside set limits, the system will not accept the values and will beep. However, an incorrect entry may still be within limits; therefore, doublecheck each parameter.
- Parameters:
  - (MILLIMETER) toggles with (INCHES), using the appropriate panel *mode* buttons.
  - DIAMETER is the substrate size, assuming it is round. (This toggles with X LENGTH/Y WIDTH.) It is sometimes recommended to set the diameter larger than the actual diameter of your substrate, to ensure that the cuts go completely across the wafer.
  - X LENGTH/Y WIDTH are used if you have, instead, a rectangular substrate. (Toggles with DIAMETER.)
  - INDEX I is the distance that the [INDEX] toggle will move the chuck when it is in the Index I position (the vacuum pin is in the 6 o'clock position.)
  - INDEX II is the distance that the [INDEX] toggle will move the chuck when it is in the Index II position (the vacuum pin is in the 9 o'clock position.)
  - DEPTH toggles with CUT DEPTH/THICKNESS.
  - If you use DEPTH, double-check your substrate stack thickness and blade exposure. You want to avoid mashing the flange of the blade into your wafer.
  - Use CUT DEPTH to specify the depth of cut into the substrate. In order to specify CUT DEPTH, you need to know:
    - THICKNESS
    - The EXPOSURE of your blade. The CUT DEPTH should be no more than 60% of the EXPOSURE of the blade. If a greater CUT DEPTH is required, try another type of blade (see section 9.)
  - THICKNESS is the total thickness of your substrate stack (including any dicing tape, double-stick tape, crystal-bond and mounting substrate.)
  - EXPOSURE is the vertical thickness of the blade. CUT DEPTH should not exceed 60% of the EXPOSURE.
  - FEED RATE is the speed (in mm/sec or in/sec) at which the blade travels across the substrate during cutting. (See NOTE below.)
  - ENTRY SPEED is the speed at which the blade first contacts the substrate. The edge of your substrate is presumed from the DIAMETER (or X LENGTH/Y WIDTH). (See NOTE below.)
  - NOTE: *parameters* [feed rate] toggles to program **both** the FEED RATE and ENTRY SPEED. There is no way to tell which way it toggles until you enter a value.
  - SPINDLE SPEED is in krpm.
  - Typical users should select *mode* [dice] & *mode* [metric] active. (When the machine has been reset, these modes will change.) Other standard parameter values and limits are given below.

PARAMETER	Min (mm)	Recommended for 4" (mm)	Max (mm)
DIAMETER	25	N/A	152
X LENGTH	1	100	152
Y WIDTH	1	100	152
INDEX I	.0025	User Select	25.3999
INDEX II	.0025	User Select	25.3999
DEPTH	.003	Not Recommended	6.350
CUT DEPTH	.003	Max is 60% of blade exposure	6.350
THICKNESS	.051	Measure entire stack with calipers	8.127
EXPOSURE	.025	Depends on blade (see section 9)	6.349
FEED RATE	.3 mm / sec	Silicon = 5; Glass = 3; Quartz = 0.1-2	406.3 mm / sec
ENTRY SPEED	.3 mm / sec	Same as Feed Rate	81.27 mm / sec
SPINDLE SPEED	4.0 KRPM	Silicon=10 krpm; Resinoid blade=22 krpm	30.0 KRPM
CLEAN WAFER	OFF	OFF	ON
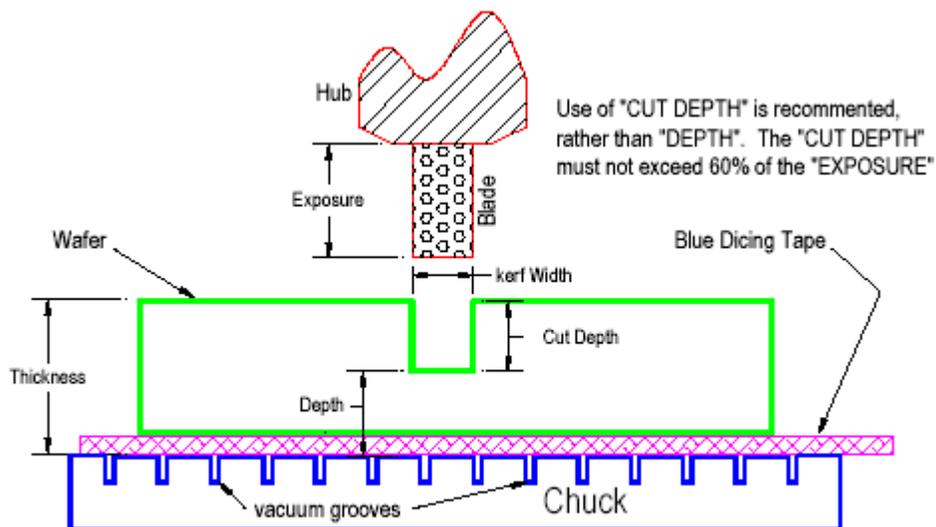
**4.3.7. Adjust the O-ring in the Chuck** to fit the wafer / sample size.

- **Select *routines* [unload]**. This turns off the chuck vacuum and turns on the air purge.
- **Pull out the vacuum pin from the chuck.** Rearrange the O-ring section of the pin as required for the wafer/sample you will be mounting. See diagram below.
- **Re-install the vacuum pin in the chuck.** Be sure it is pushed all the way into the chuck.

Chuck Vacuum Pin

Segments are screwed together and assembled as
shown to define the vacuum hold-down area of the chuck

Segments

2" wafers

3" wafers

(default) → 4" wafers

5" wafers

6" wafers
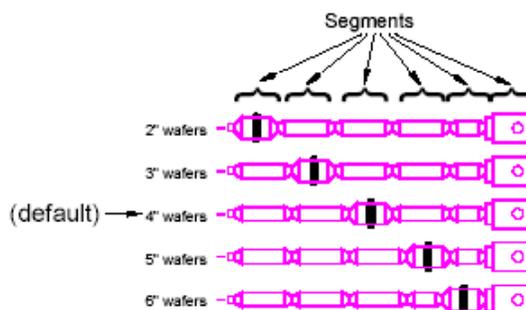
4.3.8 Load your sample
- Check the WAFER THICKNESS for your substrate on the Parameters page.
- The chuck position should be so that the vacuum pin is in the 6 o'clock position. (If not, contact a staff member.) Place your sample in center of the chuck. The the direction of your first cuts should be perpendicular to the direction of the vacuum pin. Because of the N2 backpurge, the sample may slide around a bit and you may have to hold it in place.
- **Select *routines* [load]**. Chuck vacuum is turned on. Verify that the wafer is held securely.

4.3.9 Microscope Focus Alignment. The focal depth of the microscope may need to be adjusted, as the substrate thickness may vary from wafer to wafer.
- **Select *display* [reticule]**. The monitor will now display the microscope video image.
- **Select *routines* [Align]**. The chuck moves to center of wafer.
- **Select *routines* [Inspect]**. Use **<x> & <y>** knobs to move your wafer to a pattern you can focus on.
- **Select *routines* [teach]** & then ***routines* [inspect]**
- **The <y> knob can now be used** to focus the microscope.
- **Select <enter>,** when you are satisfied with the focus, to exit the focus routine. The monitor screen will blink.

4.3.10. Street Alignment. This procedure rotates chuck so that the wafer is aligned with the cutting direction of the saw. "Street" refers to any set of points that define the alignment on your wafer. You should select an easily recognizable feature that appears in at least two locations in a line across your wafer. The easiest features to find and align are the edge of a scribeline or die edge. (The street alignment procedure is required by the software, or the system will not dice.) The system assumes your alignment features are near the middle of your wafer (near Y=0.) If your aligned features are far from the middle (i.e., the wafer flat), see section 9.

For simple two point alignment, follow the procedure below. Ideally, one point should be on the far right side, and the second one on the far left, of your wafer.

For basic four point alignment, follow the procedure below, repeating at ☼. Four-point alignment provides better alignment and is actually easier to do than two-point alignment, since this is the how the system was designed to work.

The first time through provides coarse alignment. Use two points, which can be as few as a few mm apart, on the right side of the wafer. Select the furthest right point first; the chuck will automatically jump a few mm to the left. Select your second point; the chuck will automatically rotate to align.

The second time through provide fine alignment. Use two points which are far apart. Select the right point first; the chuck will jump all the way to the left. Select your far left point; the chuck will automatically rotate to align.

For alignment on blank wafers, follow the procedure below, but do not touch the **<x>/<y> knobs** at ☼. The alignment will not change (you will have performed a "dummy" alignment.)

- **Select *mode* [index I] (or *mode* [index II])**. The chuck rotates to the Index I position, so that the vacuum pin is at 6 o'clock (or Index II, with the vacuum pin at 9 o'clock.)
- **Select *routines* [align]**. The monitor will display a prompt "move to street & select <enter> - X"
  - **Use the <x>/<y> knobs** to position the crosshairs on the **right** edge of a horizontal "street".
  - **Select <enter>**. The chuck will move slightly left. The monitor will display a prompt "move to street & select <enter> - THETA"
  - **Use the <x> and <y> knobs** to position the crosshairs on the same edge, on the **left** side of the same "street".
  - **Select <enter>**. The chuck will rotate, to align the street parallel to the saw blade. The chuck will jump to the left and ask to repeat the routine (the monitor will display the prompt "move to street & select <enter> - X".)
- To exit the routine:
- **Select *routines* [inspect]**. The system will **NOT** beep.
- **Select <enter>**. This button sequence does not make sense, but gracefully exits the alignment routine.
- **Check your street alignment:**
  - Press *routines* [inspect] to activate the **<x>** and **<y>** dials.
  - Align the cross hairs to an edge of a street.
  - Spin the **<x>** dial to check that the cross hairs remains aligned to the street edge all the way across the substrate. If so, you are ready to continue to the last alignment. If not, then repeat the alignment procedure from *routines* [align] above.

4.3.11. Y-offset Alignment
A test cut is done in a test wafer or an unimportant part of the wafer (i.e., near the flat). The purpose of the test cut is to calibrate the y-offset – that is, to align the center of the crosshair with the center of the saw blade. The y-offset must be calibrated EVERY TIME the blade is installed or power has been off. If your sample is critical, this alignment should be performed with a dummy wafer.
- **Select *routines* [inspect]**. Use the **<x>/<y>** dials to position the crosshair in a test section of the substrate.
- **Select *mode* [dice]**.
- **Select *routines* [single cut]**. The machine will make a single cut, from the right edge to the left edge of the wafer. After the cut, the chuck will move to bring the microscope approximately to the center of the cut. Use the compressed air blow-gun to blow slurry & water from the surface of the wafer and get a clear view through the microscope of the cut.
- If the crosshair is centered in the cut, then skip to section 4.6.

- If the crosshair is not centered in the cut, then:
    - **Select *routines* [inspect].**
    - **Use the <x>/<y> knobs**, to align the cut in the crosshair.
    - **Select *routines* [teach/special function], then select *routines* [align]**
    - The monitor screen will blink. The machine then exits the Y-offset routine.
    - You are now ready to cut your substrate.

4.4 Test Run: N/A

4.5 Processing

You can view your wafer through the microscope by pressing *display* **[reticle]**. By pressing *display* **[monitor]** and *routines* **[inspect]**, you can also obtain X/Y coordinates on the fly (0,0 is at the center of the chuck; +X is to the right and +Y is towards the back of the machine.)

4.5.1. Cutting in SINGLE CUT mode. This is recommended as the most accurate and dependable mode for making cuts, since this system sometimes has difficulty with long routines. This can be done for either *mode* **[index I]** or *mode* **[index II]**.

- **Select *routines* [inspect]** to activate the **<x> /<y>** knobs and **<index>** toggle.
- Position the crosshair at the desired cut location.
- **Select *routines* [single cut].** The saw will make one cut from the right side to the left side of the wafer.
- When the cut is complete, use the blow-gun to remove water from the cut area and inspect the cut.
- Repeat as desired, using *routines* **[inspect]** to enable positioning of the crosshairs, and *routines* **[single cut]** to perform the cut.
- When you are finished making all your cuts in the Index I position:
    - **Press *mode* [index II]**. This will rotate the chuck 90 degrees clockwise (the vacuum pin will be at the 9 o'clock position.)
    - Perform the street alignment for the Index II position, as described in 4.3.1.
    - Although the chuck does, indeed, rotate almost perfectly 90 degrees from the Index I position, the software requires that you perform the street alignment in the Index II position, before dicing can proceed.

4.5.2. AUTOCUTS in Single Cut mode: This can be used for either *mode* [INDEX I] or *mode* [INDEX II]

- **Select *mode* [dual cut]** until light is **OFF.**
- **Select *routines* [load]** to activate the **<x>/<y>** knobs.
- **Position the crosshair** at the first desired cut location, closest to operator.
- **Select *routines* [autocut]**. The saw will complete all cuts for the current index mode, spaced by the Parameter value for the current index mode.
- To interrupt the autocut procedure, select **<enter>**. Autocut will pause after the current cut is completed, and any other routine may be selected.
- To resume the paused autocut procedure, select **<enter>** again.

4.5.3 Making **AUTOCUTS in Dual Cut mode**:
- **Select *mode* [dual cut]** until light is **ON.** This activates the dual cut mode.
- **Select *mode* [INDEX I]**

- **Select *routines* [load]** to activate the **<x>/<y>** knobs.
- **Position the crosshairs** at the first desired cut location, closest to operator.
- **Select *routines* [autocut]**. The saw will complete all cuts at INDEX I, spaced by the Parameter value for index I. The chuck will then rotate to INDEX II, then complete all cuts for the INDEX II orientation, spaced by the Parameter value for index II.
- To interrupt the autocut procedure, select **<enter>**. Autocut will pause after the current cut is completed, and any other routine may be selected.
- To resume the paused autocut procedure, select **<enter>** again.

4.5.4. UNLOAD

When you are finished cutting, you should unload your substrate.
- **Select *mode* [INDEX I]**. The chuck will rotate to the INDEX I orientation.
- **Select *routines* [unload]**. The chuck vacuum switches off and the N2 back purge turns on to allow release of the wafer.

If you have another substrate to dice:
- Load your wafer (section 4.3.9.)
- Adjust the microscope focus, if necessary (section 4.3.10.)
- Perform the street alignment (section 4.3.11.)
- Perform dicing cuts (section 4.6.1.)
- z-Height and y-offset alignments do not need to be redone in a given session.

4.6 Standby
- Select *routines* **[unload]**. This rotates the chuck to the "INDEX I" position.
- Select *mode* **[spindle] OFF**. The spindle light should turn off.
- Clean the chuck thoroughly using the water sprayer, the N2 gun, and cleanwipes. This will ensure that grit will not dry on the chuck.
- Select **<stop>** and **<emergency stop>**. Both buttons should be lit.
- Switch **OFF** the air supply to the venturi vacuum pump.
- Turn **OFF** (1/4 turn clockwise) the green handle for the CDA supply valve.
- Turn **OFF** the monitor power switch.
- Return the O-ring for the chuck vacuum pin to the 4" wafer position.
- If you used your own blade, use the blade tool to remove your blade and replace it with another blade. Do not leave the spindle without a blade. Store the blade tool on top of the monitor, in the depression.
- Clean up and remove your personal stuff.
- Login to CORAL and disable the wafersaw. The CORAL indicator LED on top of the monitor will go OFF.

5. ROUTINE MAINTENANCE & CALIBRATION: N/A

6. SHUTDOWNS: If the machine detects a fault condition, it will undergo a self-protecting shutdown routine. It will interrupt the current routine and display the "UTILITY STATUS" information on the monitor. The possible messages are:

```
UTILITY STATUS
- - - - - - - - - - - - - - - - - - - - - - - - -
AIR PRESSURE        . . . . .      OK or LOW
POWER          . . . . . . .       OK or OFF
WATER PRESSURE . . . . .           OK or LOW
"STOP"  SWITCH      . . . . .      OK or ON
SPINDLE        . . . . . . . .     OK or OVERLOAD
CONTACT/CHUCK . . . . .            OK or BAD
```

If POWER is OFF, the head attempts to rise to ZFOCUS height as the voltage dwindles. The spindle motor shuts off. Blade cooling water shuts off. Servo motors are disabled.

If any of the other conditions are abnormal, except POWER, the machine brings the head to ZFOCUS height before disabling the servomotors. The spindle motor continues to rotate. Blade cooling water shuts off.

When all the above conditions are "OK", the countdown begins, 5 seconds for each fault condition except POWER, which is 30 seconds. The countdown is displayed at the lower right corner of the monitor. At the end of the protective shutdown period the machine returns to operator control.

7. TROUBLESHOOTING:

7.1 Common problems:

- **Completes a cut, then immediately starts cutting again:** This might be caused by a slightly sticky **<SINGLE CUT>** button. Since the second cut is in exactly the same place as the first, there is no harm is just letting it complete the cut, and continuing on as usual. (If **[STOP]** or **<RESET>** are pressed, the machine will be lock up and require maintenance to reboot. Your wafer will have to be removed and calibrations redone.)
- **Cuts part-way through the wafer,** then stops, lifts the blade, and returns to neutral position: The cause is unknown. If the stage has not been moved, just press **<SINGLE CUT>** to repeat the cut.
- **Blade starts cutting in the middle of the wafer, breaking the wafer.** This is a programming problem due to an inherent bug in the software, when DIAMETER is used. See section 9.3. The remedy is to: a. do alignment near the middle of the wafer, where Y=0; b. use DIAMETER=150 mm; c. use X LENGTH/Y WIDTH instead of DIAMETER.
- **No cut appears on the wafer.**
  - Double check the thickness of your substrate stack; make sure the value you have makes sense. If your thickness is off, you risk damaging your wafer and the machine.
  - Make sure that your units (metric versus inches) are consistent.
- **Machine appears stuck.**
  - If you are entering functions and the system appears to be stuck, first make sure you are using the correct Enter key. The **<Enter>** and *parameters* **[Enter]** are not the same; if a command isn't working for you, double check that you're using the right one.

- The computer may be locked up. The system can be rebooted (by superusers or staff) but it means that all calibrations need to be repeated. Check your setup before resorting to rebooting.
- **Interrupt/STOP the system.**
    - If you want to stop the system in the middle of a cut, press **<STOP>.** You can also press the red *routines* **[RESET]** button, but all functions are erased (you can reprogram). If you press **<STOP>,** the machine will pause for what will seem like a long time (several minutes) and then will return to neutral position. All parameters and alignments will remain the same.

7.2 Precautions you should take:

- When changing blades: Make sure to wipe the inside of the blade hub and around the spindle to remove grit. Material caught there can jam the blade onto the spindle and seriously damage the spindle over time. If the blade is difficult to remove and replace, notify maintenance.
- If the vacuum pin is <u>not</u> at 6 o'clock in the Index I position: If the pin is closer to 7:30 or 8 o'clock in Index I, when Index II is pressed, the chuck will attempt to rotate beyond its limit switch, leading to severe damage to the rotation system.   When you see this, notify a staff member or, if you feel comfortable doing so, you may realign the chuck to 6 o'clock yourself.

8. Equipment Backup: There is no equipment backup at SNF. The SNC Crystal Shop, however, has a dicing saw, available if you are a Stanford researcher. There are also several local commercial service providers listed on the website.

9. ADDITIONAL PROCESS INFO

9.1 Cutting specific substrates:

The quality of the cut you get will largely depend on the blade you use, the substrate you are cutting, and the spindle speed and feed rate. For delicate or hard substrates, feed rate can be important. The inherent stress that may have been introduced to your substrate during processing (which can result from temperature cycling, presence of high stress films or channels or membranes, etc.) may also play an important role so that, for example, settings that may work for blank quartz wafers may not work for your device wafers. If you'd like any special tips and tricks for cutting your specific substrate, you may want to contact <u>wafersaw@snf.stanford.edu</u> or check out the Kulicke & Soffa website.

GaAs/InP: Gallium arsenide and indium phosphide may NOT be cut on this saw!

Silicon: If you are cutting in the crystal plane of silicon, you can scribe the wafer -- that is, you don't need to cut all the way down through the wafer. Just specify your desired cut depth (typically 1/2 to 2/3 through the wafer). After cutting the wafer, you can gently break the die apart with little force. (The crystal planes on a <100> wafer run parallel and perpendicular to the flat.)

If you are cutting against the crystal plane (such as, 45 degrees to the flat of a <100> wafer), however, you must cut all the way down through the wafer. If you cut only part way down, the substrate will still tend to snap along the crystal plane when stressed.

Glass: Resin blades are recommended. You might use a slower feed rate (1 mm/s or less). Because glass is amorphous, you should cut all the way down through the substrate, or at least 80% of the way through.

Quartz: Resin blades are recommended, with slow feed rate (1 mm/s or less.)

Sapphire and Lithium Niobate: Resin blades are recommended for these very hard substrates. Please refer to the Kulicke & Soffa website for more process detail on how to cut these substrates.

9.2 Saw Blade selection: The type of saw blade you should use depends on what substrate you are dicing and how thick it is. Two types of blades are normally supplied in the SNF stockroom: the F3530 mounted blades and the resin blades.

- **Semitec F3530 Mounted Blades:** These blades are based on a nickel-based grit imbedded in ceramic. They are ready-mounted into disposable aluminum hubs. These are excellent for cutting silicon and provide a smooth edge (the grit is about 1-2 microns in size.) The dimensions of the ready-mounted blades are:

	F3530
Kerf Width	80 microns
Exposure	0.762 mm
Max Depth	0.457 mm

Remember, the depth you can cut into a substrate should not exceed 60% of the blade exposure. If your dicing needs require another type of blade, check out the Kulicke & Soffa website, which offers a broad range of ready-mounted blade hubs. If used only for silicon, these blades should last for hundreds, if not thousands, of cuts.

- **Resin Blades:** These blades are made of diamond grit embedded in a resin matrix. They are recommended for harder substrates, like quartz and sapphire. These must be hand-mounted in a hub flange before they can be used. The blades are all the same size; the Exposure depends on the flange used. The hubs are kept in the labelled red toolbox, just behind the wafersaw. To use these blades:
  - Obtain a resin blade from the SNF Stockroom.
  - Choose the appropriate flange from the toolbox.

	4B785-4206-000	4B785-4194-000
Kerf Width*	254 microns	254 microns
Exposure	1.63 mm	3.15 mm
Max Depth	0.978 mm	1.890 mm

(*Actual cut width is closer to 300 microns)

- Take the flange separator tool (round disk with three pins sticking up) and match the pins to the holes in the back of the hub.
- Place them on the table, with the flange separator tool on the bottom. Using fingers, press down on the center part of the flange. The flange should come apart into two rings.
- Remove the ring flanges from the flange separator tool. Place and center the resin blade in between the hub flanges. Press firmly to mount the blade between the hub plates.

- Blade is ready to use. When done, use the flange separator tool to remove your blade (keep for future use). Press the hub flanges together and return to the labelled box.

Hub Diagram:

1. Front Flange
2. Back Flange
3. O-ring
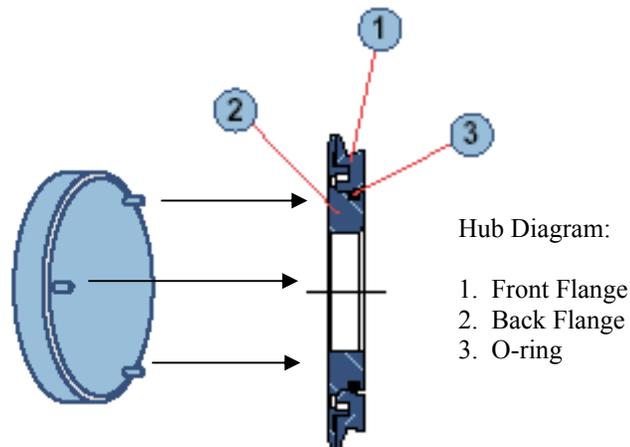
- **The S- and C-series:** We used to stock these blades and many people still use them. However, Dynatek, the manufacturer, no longer makes these blades. These blades are ready-mounted into disposable aluminum hubs. The C-series is used for harder substrates like glass and quartz (although they will not last very long with quartz.) For quartz and harder materials, use the hand-mounted resin blades. The C-series blades can also be used for silicon, but the S- series gives a much smoother edge. The S-series blades are not robust enough for hard substrates. The dimensions of the ready-mounted blades are:

	S3030/C3030	C3060/S3060
Kerf Width	80 microns	80 microns
Exposure	0.762 mm	1.524 mm
Max Depth	0.457 mm	0.914 mm

The actual cut width will be slightly larger than the kerf width (about 90-95 microns.) The Semitec F3530 is the currently stocked replacement for the S3030 blade. Semitec offers a B0445 blade which is supposed to be comparable, but because of the cost, SNF does not currently stock this.

9.3 More about programming:

- The *routines* [load/inspect] button does two functions: 1. it turns off the N2 backpurge and turns on the chuck vacuum; 2. or, if a wafers is already loaded, it enables the <x>/<y> dials and index toggle.
- The system assumes your alignment is near the middle of your wafer (around y=0.) If you are aligning far from the middle, make sure to use
- DIAMETER toggles with X LENGTH / Y WIDTH. DIAMETER assumes a round substrate, centered where Street Alignment was performed. If your alignment was done away from the center (more than about Y = +/-10 mm), then you should use X LENGTH / Y WIDTH, otherwise the blade may crash into your wafer (see Troubleshooting section 7.1.)
- DEPTH toggles Flange separator tool with CUT DEPTH. **Use of CUT DEPTH** is recommended. If you use CUT DEPTH, then WAFER THICKNESS is required. If you use DEPTH, make sure there is sufficient margin in your BLADE EXPOSURE; otherwise, you may seriously damage your substrate.

- On the Parameter screen, "CLEAN WAFER" is a water flush routine used after cutting.
- *mode* **[dice]** makes single pass per cut, from the right side of the wafer to the left side. This is recommended for smoother cuts, and minimum chipping.
- *mode* **[scribe]** makes multiple, bi-directional, passes per cut.
- *routine* **[reset]** erases all functions, but preserves parameters and height & Y-offset calibrations. The operator may then select any *routine* or *mode*. *Th*e cutting head moves to ZFOCUS height, the chuck moves to X=0, Y=0, the spindle is braked dynamically to a stop, cooling water is turned OFF, and the chuck rotates to the INDEX I orientation.
- **<air>** turns on an air-jet to dry the area to be inspected under the microscope.
- **<fast>** speeds up response from the **<x>** and **<y>** motion knobs.

APPENDIX I:
OPERATING INSTRUCTIONS (IN BRIEF)

4.1 Preparation
    4.1.1 Prepare your substrates.
    4.1.2 Measure the thickness of your sample.
    4.1.3 Make sure you can identify the lines you wish to cut.
    4.1.4 Make sure you have the correct blade for your substrate.

4.2 Equipment Setup: You should find the wafersaw clean and in Standby condition.

4.3 Startup
    4.3.1 Enable the wafersaw on Coral
    4.3.2 Change the blade.
- For safety, the **<Emergency Stop>** and **<Stop>** buttons should be lit.
- Refer to section 9.3 for blade type.
- Remember, do not overtighten the ring nut (finger-tight).

    4.3.3 Start the utilities
- **Switch the Monitor power ON**.
- **Turn ON the CDA supply**:   Turn the green CDA valve counterclockwise.
- **Turn ON vacuum pump:** The black handle on the lower right of the machine base.
- **Press <Emergency Stop>** (the button light will go off)
- **Press <Stop>** (the button light will go off) The 30 second timer counts down.

    4.3.4. Start the SPINDLE motor
- Check the Parameters page. Make sure the spindle speed is what you want.
- **Press *mode* [spindle]** and wait about 30 seconds until it comes up to speed.

    4.3.5. Calibrate HEIGHT
- **Select *routine* [unload]**. The chuck must be bare, and clean and dry.
- **Press *routine* [height]**. The chuck will move.
  - If not and the system beeps, press ***mode* [spindle]** off and then on. Wait and press ***routine* [height]** again.
- **Use the <x> and <y> dials** to center the microscope light on the chuck.
- **Select <enter>**. Z-height calibration will begin.
  - If not, press **<enter>** again. (Sometimes the **<enter>** button is sticky.)

    4.3.6 Program PARAMETERS
- To change an individual parameter:
  - select ***parameters* [change]**
  - select ***parameters* [item]** for the item to be changed
  - select ***parameters* [value]** using the numeric keys
  - select ***parameters* [enter]**.
- Parameters (see Table II for miminum and maximum acceptable values):
  - DIAMETER toggles with X LENGTH/Y WIDTH.
  - (MILLIMETER) toggles with (INCHES)

- DEPTH toggles with CUT DEPTH/THICKNESS. **Do not use DEPTH.**
- **Use CUT DEPTH** instead. CUT DEPTH should not exceed 60% of the EXPOSURE.
- THICKNESS: <u>total</u> thickness of your substrate stack.
- EXPOSURE: depends on blade used (see section 9.3).
- FEED RATE: blade travel speed during cutting. (See NOTE below.)
- ENTRY SPEED: blade travel speed at substrate edge. (See NOTE below.)
- **NOTE:** *parameters* **[feed rate]** toggles between FEED RATE and ENTRY SPEED.
- SPINDLE SPEED is in krpm.

4.3.7. Adjust the O-ring in the Chuck vacuum pin to fit the wafer / sample size.

4.3.8 Load your sample
- The vacuum pin must be in the 6 o'clock position. Place your sample in center of the chuck.
- **Select *routines* [load]**. Verify that the wafer is held securely.

4.3.9 Microscope Focus Alignment
- **Select *display* [reticule]**. The monitor will now display the microscope video.
- **Select *routines* [Align]**. The chuck moves to center of wafer.
- **Select *routines* [Inspect]**. Use **<x>** & **<y>** knobs to find a pattern to focus on.
- **Select *routines* [teach]** & then *routines* **[inspect]**
- **Now use the <y> knob** to focus the microscope.
- **Select <enter>.** The monitor screen will blink.

4.3.10. Street Alignment. (to be done with every sample.)
- **Select *mode* [index I] (or *mode* [index II])**.
- **Select *routines* [align]**. Message appears: "move to street & select <enter> - X"
- **Use the <x>/<y> knobs** to position the crosshairs on the **right** edge of a horizontal "street"
- **Select <enter>**. The chuck jumps left. Message: "move to street & select <enter> - THETA"
- **Use the <x> and <y> knobs** to position the crosshairs on the **left** side of the same "street".
- **Select <enter>**. The chuck will rotate, to align. The chuck will jump to the left and message appears: "move to street & select <enter> - X".
- **Select *routines* [inspect]**. The system will NOT beep.
- **Select <enter>**.
- **Check your street alignment**
    - *routines* **[inspect]** to activate the **<x>** and **<y>** dials.
    - Align the cross hairs to an edge of a street.
    - Spin the **<x>** dial to check alignment all the way across the substrate.
    - Repeat alignment if necessary.

4.3.11. Y-offset Alignment:
- **Select *routines* [inspect]**. Position the crosshair in a test section of the substrate.
- **Select *mode* [dice]**.
- **Select *routines* [single cut]**.
- If the crosshair is centered in the cut, then skip to section 4.5.
- If the crosshair is not centered in the cut, then:
    - **Select *routines* [inspect].**

- **Use the <y> knob**, to center the cut within the crosshair.
- **Select** *routines* **[teach/special function]**
- **Select** *routines* **[align]**
- The monitor screen will blink then exits the Y-offset routine.

4.5 Processing
4.5.1. Cutting in SINGLE CUT mode. Recommended.
- **Select** *routines* **[inspect]** to activate the **<x>** and **<y>** knobs and the **<index>** toggle.
- Position the crosshairs at the desired cut location.
- **Select** *routines* **[single cut].**
- Repeat, until you are finished making all your cuts in the Index I position:
  - **Press** *mode* **[index II]**. This will rotate the chuck 90 degrees clockwise (the vacuum pin will be at the 9 o'clock position.)
  - Perform the street alignment for the Index II position, as described in 4.3.1.

4.5.2. AUTOCUTS in Single Cut mode: See long instructions.
4.5.3 Making **AUTOCUTS in Dual Cut mode**: See long instructions.
4.5.4. UNLOAD

When you are finished cutting, you should unload your substrate.
- **Select** *mode* **[INDEX I]**. The chuck will rotate to the INDEX I orientation.
- **Select** *routines* **[unload]**. Remove your wafer.

If you have another substrate to dice:
- Load your wafer (section 4.3.9.)
- Adjust the microscope focus, if necessary (section 4.3.10.)
- Perform the street alignment (section 4.3.11.)
- Perform cuts (section 4.5.1.)

4.6 STANDBY
- Select *routines* **[unload]**.
- Select *mode* **[spindle] OFF**.
- Use water, N2 gun, and cleanwipes to clean the chuck.
- Press **<stop>** and **<emergency stop>**. Both buttons should be lit.
- Turn **OFF** the CDA supply for venturi vacuum pump.
- Turn **OFF** (1/4 turn clockwise) the green handle for the CDA supply valve.
- Turn **OFF** the monitor power switch.
- Return the O-ring for the chuck vacuum pin to the 4" wafer position.
- Remove your blade and replace it with another (do not leave the spindle without a blade.) Store the blade tool on top of the monitor, in the depression.
- Clean up and remove your personal stuff.
- Login to CORAL and disable the wafersaw.