# Model 6DS-SP Planarizer

MAINTENANCE MANUAL


VOLUME 1

STRASBAUGH

VERSION 3.0 JULY 1995

# ABOUT THE MODEL 6DS-SP PLANARIZER

The Model 6DS-SP Planarizer is designed specifically for chemical and mechanical planarization polishing of semiconductor wafers to produce uniformly flat surfaces. To achieve this goal Strasbaugh engineers have incorporated a number of enhancements over previous polishers built by Strasbaugh and by its competitors. Design emphasis has focused on maximizing potential polishing results while incorporating versatility, reliability, and simplicity of operation.

The 6DS-SP is built of special materials with optimum flatness and stable thermal characteristics. In addition to superior mechanical design, the Planarizer utilizes efficient, reliable computer and coprocessor systems for machine and process control functions. The combined benefits of state-of-the-art mechanical tolerances and machine controls provide the superior process yield potential inherent in the Model 6DS-SP Planarizer.

## A BASIC MACHINE WITH OPTIONAL FEATURES

The 6DS-SP is a basic machine with optional features available to permit the production of a specialized planarizer best adapted to meet the needs of the individual customer. The *6DS-SP Operations* and *Maintenance* manuals address the basic machine and the optional features available at time of publication.

Please maintain a list of optional features installed and retrofit changes made on your machine to facilitate support.

# MECHANICAL COMPONENTS

The machine consists of three major mechanical components, all enclosed within the machine's cabinet and a protective user enclosure to provide a sturdy, safe and clean polishing process:

- The polishing section of the machine is comprised of the polish table and associated mechanical support hardware.
- The cassette wafer handling assembly is designed to provide a safe and convenient method for robotic loading and unloading of wafers. Mechanical, electrical, and software interlocks provide for user safety during all machine operations.
- The bridge assembly, a rigid structure containing the spindle drive assemblies and their support hardware, travels on ball bearing slides to supply smooth, accurate horizontal motion of the spindle drive assemblies. The bridge traverses from the (primary) polish table to the load stations or the optional second table to facilitate transfer of wafers in process through the machine. In addition, the bridge provides the oscillatory motion of the spindle drives during wafer polishing upon the polish table. Together the rigid bridge structure and smooth oscillatory motion of the spindle drives produce wafer surface uniformity and maximize polish table pad life.

# ELECTRICAL DISTRIBUTION AND CONTROL

The Model 6DS-SP Planarizer's electrical distribution and control systems are designed to provide all necessary control functions for polish process optimization while maintaining the reliability and ease of use necessary for the production environment.

The focus of the control system is the control computer, an IBM Industrial PC-AT personal computer, supplying maximum reliability and functionality in an industry standard package. A high resolution color monitor and keyboard interface the planarizer with the user through menu-oriented commands displayed on the monitor. The fixed or mobile remote terminal option provides a second monitor mounted over the elevators or on a mobile cart. The planarizer design takes advantage of such benefits inherent in the application of a personal computer for process control as widespread hardware availability and support, understanding of PC operation among users and engineers, and very cost effective performance due to large scale production of PC's for factory applications.

The 6DS-SP uses a standard "off the shelf" computer package rather than a customized card cage to maintain simplicity, reliability, and economy. In addition to the control computer and interface hardware, the control system includes an industry standard input/output (I/O) system. A second computer board resides in the control computer for dedicated control of six or more of the planarizer's servo motor axes, with a third computer board controlling the other eight servo motor axes. Together the I/O, servo controllers, and control computer maintain communication for complete control of all machine functions.

# SAFETY

**The 6DS-SP Planarizer has been designed for safe operation. However, caution should be exercised while operating this machine. Failure to adhere to the following safety instructions and to good safety practices may result in injury to personnel or damage to the machine.**

**It is the responsibility of the user to be sure that the machine is in safe operating condition at all times. The user is also responsible for insuring that the operator follows all proper and safe operating procedures. The following is a list of safety instructions:**

## GENERAL OPERATION

- Operating the machine with loose wafers inside is harmful to the machine and wafers - **Follow the procedures in the Troubleshooting chapter of this manual for removing loose or broken wafers.**
- **DO NOT** at any time put hands or objects beyond the Operator Doors while the polish table is in motion.
- Keep all guards and covers in place and in good repair.
- **DO NOT** bypass safety interlocks.
- Keep all control and electrical cabinet doors closed and latched.
- Disconnect power when servicing or repairing the machine.
- **DO NOT** operate the machine without proper electrical grounding.
- **DO NOT** wear loose clothing which could be caught by machine parts in motion.
- Wear **SAFETY GLASSES** whenever working near moving machinery.

| | |
|---|---|
| **CAUTION!** | Do not move the bridge with an unloaded carrier in the machine. Severe machine damage may result. |

# New Features Information Locator

The Version 4.00 software introduces a number of new features not available in previous software versions. The table below lists each feature, the menu(s) at which it is found, and where in the 6DS-SP *Operations* and *Maintenance* manuals to find detailed information on the feature.

| Feature | Menu(s) | Where To Find Details - Manual Location(s) |
|---|---|---|
| EXPANDED PASSWORD PROTECTION | Password Menu | Operations:<br>•Ch. 4-Machine Setup |
| OPTIONAL OPERATOR ACCESS TO POLISH TIME AND BACKPRESSURE POLISH PARAMETERS | Calibration/Configuration Menu | Maintenance:<br>•Ch. 10-Software Calibration<br>•Appendix A-Calibration Variables |
| PRESETTABLE WAFER POLISH COUNT | Auto Polish Menu<br>Auto Polish Parameters Menu | Operations:<br>•Ch. 3-Operator Functions<br>•Ch. 4-Machine Setup |
| ODD WAFER POLISHING | Machine Parameters Menu<br>Auto Polish Menu | Operations:<br>•Ch. 3-Operator Functions<br>•Ch. 4-Machine Setup |
| DUAL BACKPRESSURE CONTROL | Auto Polish Parameters Menu | Operations:<br>•Ch. 4-Machine Setup |
| DUAL TIME AND DUAL BACKPRESSURE ENTRY CHOICES | Machine Parameters Menu<br>Auto Polish Menu<br>Auto Polish Parameters Menu | Operations:<br>•Ch. 3-Operator Functions<br>•Ch. 4-Machine Setup |
| ERROR LOG | Error Log Menu | Operations:<br>•Ch. 5-Troubleshooting<br>Maintenance:<br>•Ch. 13-Troubleshooting |
| IN-SITU CONDITIONING DUTY CYCLE | Conditioning/Cleaning Parameters Menu | Operations:<br>•Ch. 4-Machine Setup |

| Feature | Menu(s) | Where To Find Details - Manual Location(s) |
|---|---|---|
| EASIER PROGRAMMABLE PAD CONDITIONING ARM CALIBRATION AND SETUP | Calibration/Configuration Menu<br>Sweep Parameters Menu<br>Manual Control Menu | Operations:<br>•Ch. 4-Machine Setup<br>Maintenance:<br>•Ch. 9-Mechanical Maintenance:<br>•Ch. 10-Software Calibration<br>•Appendix A-Calibration Variables |
| POLISH AND CONDITION FORCE UNITS AND DIAMETER ENTRY CHANGE | Machine Parameters Menu<br>Conditioning/Cleaning Parameters Menu | Operations:<br>•Ch. 4-Machine Setup |
| MENU " HOPPING " | Available At All Menus | Operations:<br>•Ch. 3-Operator Functions (topic: Menu Selection) |
| "ON THE FLY CHANGES" | Auto Polish Menu<br>Process Parameters Menus | Operations:<br>•Ch. 3-Operator Functions<br>•Ch. 4-Machine Setup |
| ADDED AUTO CYCLE FEATURES | Auto Polish Menu | Operations:<br>•Ch. 3-Operator Functions |
| EXPANDED MANUAL CONTROL MENU | Manual Control Menu | Maintenance:<br>•Ch. 9-Mechanical<br>•Ch. 10-Software Calibration |
| EASIER SERVO CALIBRATION | Manual Control Menu<br>Calibration/Configuration Menu<br>Diagnostics Menu | Maintenance:<br>•Ch. 9-Mechanical<br>•Ch. 10-Software Calibration |
| "LEVER TYPE" CONDITIONING ARM SUPPORT | Calibration/Configuration Menu | Maintenance:<br>•Ch. 10-Software Calibration<br>•Appendix A-Calibration Variables |
| "SINGLE" SWEEP STYLE CHOICE | Conditioning/Cleaning Menu | Operations:<br>•Ch. 4-Machine Setup |
| WET IDLE SLURRY FLUSH | Machine Parameters Menu<br>Slurry Flush Menu | Operations:<br>•Ch. 3-Operator Functions<br>•Ch. 4-Machine Setup |

| Feature | Menu(s) | Where To Find Details - Manual Location(s) |
|---|---|---|
| LIGHT TOWER SUPPORT | n/a | Operations:<br>•Ch. 2-Machine Description<br>•Ch. 3-Operator Functions<br>Maintenance:<br>•Ch. 2-Physical Description |
| UNIVERSAL CASSETTE SUPPORT | Calibration/Configuration Menu | Maintenance:<br>•Ch. 10-Software Calibration<br>•Appendix A-Calibration Variables |
| PRE OR POST PAD CONDITIONING | Conditioning/Cleaning Parameters Menu | Operations:<br>•Ch. 4-Machine Setup |
| SCRUBBER SUPPORT | Machine Setup Menu<br>Calibration/Configuration Menu<br>Manual Control Menu | Operations:<br>•Ch. 4-Machine Setup<br>Maintenance:<br>•Ch. 10-Software Calibration<br>•Appendix A-Calibration Variables |
| SLURRY ALARM ACTION NOTICE | Alarm Parameters Menu<br>Calibration/Configuration Menu | Operations:<br>•Ch. 4-Machine Setup<br>Maintenance:<br>•Ch. 10-Software Calibration<br>•Appendix A-Calibration Variables |
| POST POLISH SLURRY FLUSH | Machine Parameters Menu | Operations:<br>•Ch. 4-Machine Setup |

### Vacuum Separator

| Related Engineering Drawings | |
|---|---|
| • 219771A1 | Vacuum System Assembly |
| • 219771P1 | Vacuum System Diagram |

## Exhaust

The **machine exhaust duct (4)** connection is to a vacuum source rated at approximately 250 SCFM. A six-inch duct or hose is required to connect to the exhaust duct.

## Temperature-Controlled Water

The **coolant in (11)** and **coolant out (6)** permit the cycling of temperature-controlled water through the polish table for a temperature-controlled polishing process. Both connections require mating to the machine's 3/4-inch PVC threaded pipe joints. The pressure regulator adjusts the pressure of the liquid flowing through the loop. The **coolant in (11)** and **coolant out (6)** must be connected to the temperature control unit.

A bypass valve, **coolant bypass (11A)**, mounted at the rear of the machine, provides overpressure protection for the polish table. If coolant back pressure rises above 10 PSI, the coolant bypass valve opens and dumps to the **table drain (8)** to prevent damage to the table.

### Temperature Control Unit

| | |
|---|---|
| • Manufacturer's Data | Neslab HX-150 Temperature Control Unit |

For connection of utilities to the temperature control unit, refer to the Neslab documentation in the Manufacturers' Data section of the Appendices of the *6DS-SP Maintenance* manual.

## GENERAL FACILITIES AND ELECTRICAL SERVICE DATA SHEET

### R.Howard Strasbaugh Inc.
### Model 6DS-SP
### General Facility and Electrical Service Data

| Component | Width (In) | Depth (In) | Height (In) | Weight (lbs) | Electrical (Volt/Ph/Freq) | Circuit Breaker (Amps) |
|---|---|---|---|---|---|---|
| Planarizer | 100 | 72 | 80 | 8500 | 208/3/60 | 60 |
| Vacuum System | 30 | 21 | 60 | 150 | optional | optional |
| Temp. Control Unit | 26 | 21 | 40 | 350 | 208/1/60 | 30 |
| Slurry Tank(2) | 23 Dia. | | 23 | 275 | none | none |

### Facility Services Data

| Component | Service | Service Size | Connector | Peak Flow | Average Flow | Pressure | Remarks |
|---|---|---|---|---|---|---|---|
| Planarizer | D.I. Water Supply | 1/2" | 3/8" FNPT | 6 GPM | 3 GPM | 30-45 PSI | |
| | D.I. Water Return | 1/2" | 3/8" FNPT | * | * | * | * Unrestricted return |
| | CDA | 1/2" | 3/8" FNPT | 10 SCFM | 3 SCFM | 100 PSI | |
| | Vacuum | 3/8" | 3/8" comp | 1 SCFM | .5 SCFM | 20" Hg min. | |
| | Exhaust | 6" | 6" exhaust | 250 SCFM | 250 SCFM | 1/2 water col. | |
| | Industrial Waste | 1-1/2" | 1-1/2" FNPT | 5 GPM | 1-1.5 GPM | none | Table Drain |
| | Industrial Waste | 1-1/2" | 1-1/2" FNPT | 5 GPM | 2 GPM | none | Loader Drain |
| | Coolant Inlet | 3/4" | 3/4" FNPT | 6 GPM | 3-4 GPM | 10 PSI | Connect to Temp. Control Unit |
| | Coolant Outlet | 3/4" | 3/4" FNPT | 6 GPM | 3-4 GPM | < 5 PSI | Connect to Temp. Control Unit |
| Vacuum System (optional) | Vacuum Supply | 3/8" | 3/8" FNPT | see above | see above | see above | Connect to Planarizer |
| | Industrial Waste | 1/2" | 1/2" tube | 1 GPM | 0.5 GPM | none | Connect to Planarizer |
| | CDA | 1/4" | 1/4" tube | 1 SCFM | 0.1 SCFM | 30 PSI | |
| Temperature Control Unit (optional) | Coolant Outlet | 3/4" | 3/4" NPT | see above | see above | see above | Connect to Planarizer |
| | Coolant Return | 3/4" | 3/4" NPT | see above | see above | see above | Connect to Planarizer |
| | Industrial Water | 3/8" | 3/8" barb | 5 GPM | 1 GPM | 30 PSI Max. | For refill only |
| | Chilled Water Supply | 1/2" | 1/2" NPT | 4 GPM | 1 GPM | 10 PSI | For water-cooled compressor |
| | Chilled Water Drain | 1/2" | 1/2" NPT | 4 GPM | 1 GPM | 0 PSI | |
| | Reservoir Drain | 1/2" | 1/2" NPT | 1 GPM | 0 GPM | 0 PSI | |
| Slurry Tank (2 tanks) | Slurry Bypass(2) | 1/4" | 1/4" tube | --------- | --------- | --------- | Connections supplied by RHS |
| | Slurry Supply(2) | 1/2" | 1/2" tube | --------- | --------- | --------- | Connections supplied by RHS |
| | Slurry Return(2) | 3/8" | 3/8" tube | --------- | --------- | --------- | Connections supplied by RHS |

Rev.(6-2-94) Specifications subject to change without notice.

# FACILITIES CONNECTIONS

The section below describes the utility sources required for 6DS-SP operation and procedures for making utility and slurry connections to the machine.

## CONFIRMING THAT UTILITY SOURCES MEET REQUIREMENTS

**IMPORTANT:** The necessary utilities must meet the required specifications (shown below) in order for the Model 6DS-SP Planarizer to operate correctly.

The following list identifies the minimum facilities requirements for the machine:

- Electrical: 208 VAC, THREE-PHASE 60 Hz, 60 FLA
- Clean Dry Air: 100 PSI, 10 SCFM
- Vacuum: 25 in. Hg
- D.I. Water: 35 PSI minimum
  40 PSI maximum

  (Note that teflon D.I. water plumbing is now standard on all machines.)
- Acid Drain: 1-1/2-in. pipe
- Industrial Waste Drain: 1-1/2-in. pipe
- Exhaust 6-in. duct, 250 SCFM

# MECHANICAL DESCRIPTION

## OVERVIEW

This chapter provides a detailed narration of the sequence of machine events comprising the auto polish cycle followed by descriptions of the mechanical assemblies and components participating in the cycle functions.

## AUTO POLISH CYCLE OPERATION - THE SEQUENCE OF EVENTS

Assumptions - the events sequence (A. through F., below) was written with the assumption that the machine has been

◊ correctly installed and maintained, per procedures found in the 6DS-SP Maintenance manual.

◊ correctly setup, per procedures in the Machine Setup chapter of the 6DS-SP Operations manual for setup of auto polish cycle parameters, machine setup parameters, pad and carrier conditioning parameters, alarm parameters, slurry flush parameters, and program data storage.

◊ powered up, homed, and prepared for an auto cycle, per procedures found in the Operator Functions chapter of the 6DS-SP Operations manual.

### A. CASSETTE LOADING

The operator

1. places a filled cassette on a send elevator.
2. lowers the elevator cassette sensor arm.
3. places an empty cassette on a receive elevator.
4. lowers the elevator cassette sensor arm.
5. closes the elevator door.
6. presses the <CYCLE START> pushbutton on the control panel.

# B. Wafer Loading Sequence

1. The send elevator moves to Slot 1.
2. The robot arm extends into the cassette.
3. The robot vacuum is turned on and the robot Z travels from its top position to its bottom position.
4. The wafer sensor is checked to verify the presence of a wafer in the current slot.
5. If no wafer is found, the vacuum is turned off, the robot Z moves to its top position, the robot arm is retracted, the send elevator is indexed to the next slot, and the process is repeated from step 2.
6. When the wafer is sensed, the robot Z moves from its bottom to its middle position.
7. The robot arm retracts out of the cassette with the wafer.
8. The robot travel moves from the send cassette position to the left/right load position.
9. The robot Z moves to its Z position above the load station.
10. The robot arm moves out over the load chuck.
11. The load chuck travels to its up position.
12. Vacuum at the load chuck is turned on to sense the wafer.
13. The robot Z moves from its position above the load station to its Z left/right load position.
14. Vacuum to the robot vacuum chuck is turned off.
15. The robot Z travels from its left/right load station position to its Z above load station position.
16. The robot arm retracts back to the arms home position over the robot carriage.
17. Vacuum at the load chuck is turned off and the load chuck moves down and seats the wafer.
18. When one or both wafers is seated in the load chuck(s), the spindles travel down.
19. The load chuck and carrier vacuums are turned on, and the load chuck lifts the wafer to the spindle.
20. The load chuck releases vacuum.
21. The load chuck goes down.
22. The spindle goes up.
23. The bridge moves to polish position over table 1 if time has been entered at the Parameters Menu for the left or right spindle in steps 1 through 10. On two table machines, the shuttle is retracted prior to the bridge move to table 1.

## C. POLISH CYCLE SEQUENCE

1. The spindles move down to the table.
2. The polishing sequence begins.
3. Step 1 timing begins with spindles rotating at the programmed speed.
4. Spindle down force and back pressure on the wafer start to ramp up.
5. The cycle times out.
6. Down force is reduced to near zero.
7. Back pressure vacuum to the wafer is turned on.
8. When back pressure vacuum reaches the required level, the spindles lift off the table.

9. If the second table option is not installed, the wafer unloading sequence begins (refer to Section D, below).

10. If the second table option is installed:
    a. The bridge moves to polish position over the second table if time has been entered at the Polish Parameters Menu for the left or right spindle in steps 11 through 20.
    b. The polishing sequence begins.
    c. Step 11 timing begins with spindles rotating at the programmed speed.
    d. Spindle down force and back pressure on the wafer start to ramp up.
    e. The cycle times out.
    f. Down force is reduced to near zero.
    g. Back pressure vacuum to the wafer is turned on.
    h. When back pressure vacuum reaches the required level, the spindles lift off the table.

# D. Wafer Unloading Sequence

1. A test is done to make sure wafer(s) are on spindle(s).
2. The bridge moves to its load position.
3. If wafer cleaning is enabled:
   a. The shuttle moves back.
   b. The spindles move down into the cleaning stations.
   c. The spindles rotate according to the wafer cleaning parameters set.
   d. When wafer cleaning is finished, the spindles rise.
   e. The shuttle moves forward.
   f. The spindles move down to the load stations.

   *or*

4. If wafer cleaning is not enabled, the wafer cleaning sub-sequence is skipped.
5. The spindles move down to the load stations.
6. Vacuum is turned off, and blow off is turned on to the wafer.
7. The wafer falls into the load ring.
8. Blow off is turned off.
9. The spindles rise.
10. If time has been entered for wafer rinsing, wafers are rinsed.
11. The robot travel moves to its left/right load position.
12. The robot Z moves to its above load position.
13. The robot arm extends out over the load station.
14. The load chuck turns on vacuum and moves up.
15. The robot Z moves down to its left/right load position.
16. The robot vacuum turns on.
17. The load chuck turns vacuum off, releasing the wafer.
18. The robot Z moves to its above load position while holding the wafer.
19. The robot arm retracts back to its home position over the robot carriage.
20. The receive elevator moves to the next empty slot.
21. The robot travel moves to its receive elevator position.
22. The robot Z moves to its middle position at the receive elevator.
23. The arm extends into the cassette.
24. The robot turns off vacuum, releasing the wafer.
25. The robot Z moves from its middle position to its top position.
26. The arm retracts back to its home position over the robot carriage.

**Notes:** **For both one and two table machines:** If spindle flush is enabled, when wafers are removed from the load chucks by the robot, a spindle flush starts.

**For two table machines only:** The carriers are cleaned by rotating while being sprayed with D. I. water.

27. If carrier cleaning is enabled:

    a. The shuttle moves backward to its rear position.
    b. The spindles move down into the cleaning stations.
    c. The spindles begin rotating as the carrier cleaning cycle begins.
    d. When the cleaning cycle is finished, the spindles move up.
    e. The shuttle moves forward.
    f. The machine begins the next auto cycle.

    *or*

28. If carrier cleaning is not enabled, the carrier cleaning sub-sequence is skipped.

29. The machine begins the next auto cycle.

## E. Cassette Removal

The operator

1. opens the elevator doors.
2. raises the elevator cassette sensor arm.
3. closes the elevator doors and waits for the elevators to rise to slot 26.
4. removes the cassette of processed wafers from the receive elevator.

## F. Cycle Halt

- The operator presses the <CYCLE HALT> pushbutton on the control panel.

For further details on cycle termination and choices available at the Auto Polish Cycle menu when no cycle is running, refer to the Operator Functions chapter of the 6DS-SP Operations manual.

# BRIDGE DRIVE ASSEMBLY

The bridge assembly encloses and supports the left and right spindle assemblies and their associated hardware. The bridge assembly moves the wafer carriers between the load stations and the polish table; during the polishing cycle it oscillates the wafer carriers and wafers over the surface of the polish table. The bridge also oscillates over the second polish table when the second table option is installed.

The bridge assembly is supported by two rails mounted on a solid framework. Four linear bearing blocks, attached to the underside of the bridge assembly, ride along the top of the rails. The drive assembly is a recirculating ball and lead screw supported by the machine's framework at each end. Two pulleys and a toothed drive belt connect the lead screw to a brushless DC servo motor. This arrangement converts motor drive force into linear motion, moving the bridge assembly left or right between the load stations and the polish table. The motor, mounted to the machine's framework in the right side rear of the machine, is accessible through the lower right side service door. Limit switches at each end of the rails ensure the bridge assembly does not "run away", crashing into the side walls of the machine. Encoder feedback constantly reports back to the control computer the exact position and velocity of the bridge assembly.

If the **curtain rinse option** is installed, after polishing the bridge pauses between the polish table and the load stations to permit an extra rinsing of the carriers. Curtain rinse type is chosen at page 2 of the Machine Parameters Menu. Curtain rinse is enabled/disabled at page 3 of the Machine Parameters Menu. Curtain rinse time is selected at page 3 of the Machine Parameters Menu. Table rinse with curtain rinse is also enabled/disabled at page 3 of the Machine Parameters Menu.

# ELEVATOR ASSEMBLY

The elevator assembly, located at the left of the machine, consists of two functional units, send and receive. The left and right send elevators, located at the rear of the machine, raise and lower cassettes loaded with unprocessed wafers. The left and right receive elevators, located near the middle of the machine, raise and lower cassettes loaded with processed wafers.

The elevator back support houses a polymer nut and two pillow block bearings. The bearings travel on a rail supported by the framework of the elevator slide assembly. The polymer nut is stationary, and a lead screw is rotated inside the nut. The lead screw is supported at both ends by bearings mounted on the slide assembly. The lead screw is belt-driven by a brushless DC motor with a tooth belt and two pulleys. The motor has uses encoder feedback to monitor speed and position. The elevator home switch, located two to three inches from the end of travel, is used to tell the control computer when the elevator has reached the bottom limit of travel. This information is used to "home" the elevator. Note that the elevators are water-resistant.

Each of the four cassette sensor arms has a mechanical microswitch located in the end of the arm. Lowering an arm onto a cassette trips the microswitch, informing the control computer that a cassette has been placed on the elevator.

The elevators sit in tanks supplied with water from an air operated valve controlled by a solenoid valve mounted on the valve panel located at the lower left side of the machine.

**The elevator light sensor option** detects any wafer not correctly (and safely) positioned in its cassette slot. The incorrectly positioned wafer will break an invisible infrared light beam. When the beam is broken, indicating the wafer is not positioned close enough to the rear of the slot, downward movements of the elevator, which could break the wafer, are not permitted. After a five-second delay, an alarm will sound, and a message will be displayed on the monitor screen. The five-second alarm delay prevents false alarms from normal light beam interruptions such as the robot inserting a wafer. The light sensor detection is active only if the elevator arm is lowered onto a cassette.

When the elevator access door is closed, **the elevator automatic fill and drain valve feature** automatically keeps the elevator tanks filled with water whenever cassettes are present on the elevators. If an elevator arm is lifted, its tank will begin draining. The drain valve will remain open as long as the arm is lifted. If the elevator had been filling, the fill valve will now close.

Any raising or lowering of cassette arms for the purpose of controlling fill/dump valves is ignored when the elevator access door is open. Only when the door is closed will the arm switches be monitored to control the valves. This feature is mainly intended to permit removal of polished wafers from a receive cassette without disturbing the elevator tank fill/dump valves.

If an elevator arm is lowered and the elevator access door is closed, the elevator's tank will fill for the time period entered for calibration variable 179. If more than one arm is lowered, the tanks will be filled one at a time. The first arm lowered always determines the first tank to fill. If additional arms are then lowered, the following filling priority is used:

1. Active receive cassette's tank (it will be the first to receive wafers).
2. Active send cassette's tank (if in "dunk send" mode).
3. Inactive send cassette's tank (if in "dunk send" mode).
4. Inactive receive cassette's tank (it will be the last to receive wafers).

If the "dunk send" (calibration variable 180) mode is not enabled, the send cassette tanks will never be filled. If the machine is not equipped with automatic fill and drain valves, the fill time entered for calibration variable 179 will have no effect.

# ROBOT ASSEMBLY

Supported by a slide assembly, the robot travels between the left elevators and the right load station, stopping at each elevator and load station (a range of approximately three feet). The slide assembly is comprised of two hardened steel rails and a lead screw supported at both ends. On the right end of the lead screw, a brushless DC motor is connected by direct drive through a flexible coupling to the lead screw. Four linear pillow block bearings mounted underneath the robot base slide on the hardened steel rails. The lead screw is rotated within a stationary polymer nut located underneath the robot base, causing linear movement of the robot. Encoder feedback monitors position and speed.

The robot's Z-axis provides up and down linear travel. Located inside the rectangular housing, the Z-axis has a backplate mounted with three linear bearings mounted on a spine shaft at the center of the housing. A stationary lead screw (located inside a nut mounted in two bearings on the framework of the robot) is rotated by a brushless DC motor driving a tooth belt and two pulleys, causing upward and downward movement of the robot. Encoder feedback monitors position and speed. The Z-axis has a single inductive sensor located at the middle range of travel and functioning as a "home" switch.

The robot rotational (theta) axis is belt driven by a brushless DC motor (mounted inside the robot assembly), two pulleys, and a tooth belt. An inductive sensor located inside the housing "homes" the theta axis. Encoder feedback monitors position and speed.

The robot radial axis (also belt driven by a brushless DC motor, two pulleys, and a tooth belt) is mounted on a spindle located in the end of the theta axis housing. The spindle is driven by two pulleys and a belt. The belt and pulleys are driven by a shaft (driven by two more pulleys, a belt, and a motor) extending down inside the robot assembly. An inductive sensor located on the underneath side of the housing "homes" the radial axis. Encoder feedback monitors position and speed.

The robot's radial and theta axes permit it to reach into wafer cassettes and out over the load stations, positioning an end effector located on the theta axis over a wafer. The end effector is a vacuum chuck fitted into the end of the theta axis. The vacuum chuck picks up and deposits wafers to and from elevators and load stations. The end effector is equipped with a vacuum switch, located inside the housing, to sense when the robot has taken vacuum on a wafer.

# LEFT/RIGHT LOAD/UNLOAD STATIONS

Each load station is equipped with a load chuck mounted on an air cylinder (which raises and lowers the chuck). The load chuck takes vacuum on a wafer through vacuum ports. The load chuck lowers the wafer into the centering ring which has beveled sides to aid in centering the wafer in the ring. A vacuum sensor, mounted on a bracket located on the cabinet wall adjacent to the load station, notifies the control computer when a wafer is placed in the ring. A rinse nozzle mounted on each ring wets the wafers before and after polishing. Load chuck rinsing during polish cycles is selectable at page 3 of the Machine Parameters Menu with choices available for rinsing at intervals, rinsing steadily, or no rinsing. Both the left and right load chucks will be rinsed even if only one spindle is in use. Load chuck rinsing does not occur in "condition" mode.

**The fountain rinse option** provides rinsing of the front side of the wafer as a part of the post polish wafer handling sequence. For machines equipped with fountain rinsing, the function is enabled at page 3 of the Machine Parameters Menu.

# LEFT/RIGHT CARRIER/WAFER CLEANING STATIONS

The carrier/wafer cleaning stations rinse and scrub carriers and wafers. The stations can rinse both carriers and wafers at all times, but they can scrub only the item (carrier or wafer) for which the appropriate brush is installed. Each cleaning station is equipped with a cleaning device powered by a brushless DC servo motor. The cleaning device is mounted on an air cylinder which raises and lowers the it during cleaning. A rinse nozzle mounted inside the station sprays D. I. water on the carrier/wafer. Polymer rollers mounted in each cleaning station permit the carriers/wafers to rotate during cleaning.

# SHUTTLE ASSEMBLY

The shuttle assembly is comprised of the base plate and top plate sections. Two hardened steel rails, two shock absorber hard stops, and an air cylinder which actuates linear movement of the shuttle assembly are mounted on the base plate. The air cylinder has a magnetic reed switch on each end to notify the control computer whether the shuttle is in forward or back position. The top plate is equipped with four bearing blocks which roll along the hardened steel rails mounted in the base plate. The cleaning and load stations are mounted on the top surface of the top plate.

On machines equipped with a second polish table, the shuttle assembly uses locks operated by an air cylinder with reed switches to lock the table in its back (polish) position. Machines with a second table installed have three plates with two sets of hardened steel rails and bearings and one air cylinder.

# POLISH TABLE DRIVE ASSEMBLY

The polish table drive assembly consists of a brushless DC servo motor, worm gear reduction gearbox, shaft, and granite table. The brushless DC servo motor is speed controlled by a servo controller, discussed in detail in the Control System Description chapter of the 6DS-SP Maintenance manual. The motor is bolted directly to the worm gear reduction gearbox. The gearbox is mounted to a box beam of the machine's framework along the backside and to an angled support beam at the front.

A drive shaft milled out of eight-inch steel stock runs through the middle of the gearbox. The drive shaft is keyed to the drive train of the gearbox. The top of the drive shaft has a flange head to which a subtable of 2 1/4- inch thick steel is mounted.

The two-layer (granite top layer, stainless steel bottom layer) table assembly, 28 inches in diameter and six inches thick, is mounted to the subtable. The drive shaft is hollow to permit routing of temperature-controlled water in and out of the table. A rotary joint at the bottom of the drive shaft accommodates plumbing of the inlet and outlet water lines.

A velocity command signal from the control computer instructs the velocity controller to ramp the motor up to the programmed speed. The gearbox turns the shaft, subtable, and granite table all as one unit, accelerating to constant speed. A resolver, mounted on the motor, feeds back the velocity and acceleration of the assembly to the control computer. The speed of the table is measured in revolutions per minute (RPM) and displayed in real time on the monitor. Rated table speeds vary with the reducer ratio of the gear box installed in the machine. Calibration variable 62 displays the table reducer ratio. Note the ratios shown below:

| | |
|---|---|
| 7.5: 1 | maximum 250 rpm |
| 10: 1 | maximum 160 rpm |
| 15: 1 | maximum 125 rpm |

# SPINDLE DRIVE ASSEMBLY

The spindle drive assembly consists of a brushless DC servo motor mated with a gear reducer assembly, the quill shaft assembly, and the wafer carrier mounting assembly. The motor mounting block and quill housing are bolted together. They support the entire spindle drive assembly. The mounting block serves as an attachment point for the spindle force assembly (discussed further in the section below). The quill housing contains the quill shaft assembly which rides on linear ball bushings inside the linear housing. The linear housing is affixed to the bridge assembly framework. This arrangement permits vertical movement of the spindle drive assembly. A stop adjustment prevents the spindle drive assembly from contacting the polish table whenever a wafer carrier is not attached to the end of the shaft.

The quill shaft assembly is the actual drive shaft which rotates the wafer carrier on the polish table. Manufactured from two-inch steel stock with a hollowed center, it rides inside the quill housing on linear ball bushings. The brushless DC servo motor and reducer assembly mount directly to the quill shaft. A bracket support and torque arm prevent its rotation. At the bottom end of the quill shaft is a mounting flange supporting the wafer carrier mounting assembly.

The wafer carrier mounting assembly has a flat underside with an aluminum chuck equipped with 0 rings. The 0 rings form two vacuum chambers between the chuck and the carrier. An applied vacuum source evacuates air from one chamber to firmly attach the wafer carrier to the spindle drive assembly. The end of the quill shaft is a ball joint for alignment to the center of the wafer carrier. Vacuum for this runs between the back pressure feed tube and the quill shaft wall. The vacuum fills the space not taken up in the quill shaft by the back pressure feed tube, providing the vacuum source required to attach the wafer carrier to the wafer carrier mounting assembly. The feed tube, which supplies back pressure to the wafer during polishing, transferring air and vacuum (as well as water for carrier flushing), is located inside the quill shaft, running the entire length and extending out the top above the servo motor. A rotary joint is mounted to the top of the feed tube. The vacuum supply line attaches to the quill shaft.

To secure the wafer during polish liftoff and cleaning, controlling wafer position and preventing breakage, the spindles use back pressure technology, transferring air or vacuum as needed (to retain or release the wafer) down through the carrier to the wafer. Back pressure is used for wafer transport and unloading whether or not it is enabled for polishing.

During wafer transport to and from the table, the machine will attempt to apply the minimum back pressure of 0 PSIA (-14.7 PSIG) of vacuum. This condition encourages the wafer to remain on the carrier. The actual minimum reached, shown on the status display, will be several PSIA or PSIG below atmosphere. During unloading, back pressure is used for wafer blow off. During idle times, the source for back pressure is set to a nominal value near atmosphere, but this source is disconnected from the carrier. Instead, the carrier is vented to atmosphere.

During polishing, selectable and controllable pressure is routed through the spindle and carrier to the back side of the wafer. This pressure may be displayed in either PSIA or PSIG (absolute pressure which is the pressure above perfect vacuum) on the status display at the right side of the display screen by setting calibration variable 65 at the Calibration/Configuration Menu. If enabled at page 1 of the Machine Parameters Menu, back pressure will be used during polishing. If not, the back side of the wafer is vented to atmosphere during polishing. Enabling or disabling back pressure during polishing has no effect on the other functions of back pressure, used when not polishing.

# SPINDLE DOWN FORCE ASSEMBLY

The spindle raise force assembly function is determined by springs located inside the raise force air cylinder. The springs move the piston which retracts the air cylinder rod, pulling on the back end of the lever arm. The lever then raises the spindle.

The spindle down force assembly consists of the spindle drive assembly, a lever arm, an air cylinder, a load cell, and an electro-pneumatic regulator. (This structure is identical for both the left and right spindles.)

The air cylinder is the origin of the force applied to the spindle drive assembly and wafer carrier. A series of connecting rods and a lever arm transmit the force of the air cylinder to the spindle drive assembly. The load cell senses the amount of applied force on the spindle drive assembly and wafer carrier and generates an analog voltage signal proportional to the amount of force. This signal is amplified and transmitted to the control computer through an analog input channel. The control computer receives the information and compares it to the programmed value of required spindle down force. The control computer regulates the applied force by regulating the air flow to the air cylinder with the electro-pneumatic regulator. The control computer generates an analog voltage signal for the electro-pneumatic regulator, and the regulator adjusts the air pressure in proportion to the voltage level of the signal. Together the control computer, load cell, and electro-pneumatic regulator form a closed loop controller to maintain the downward spindle force within 2% of the programmed force value in pressure mode.

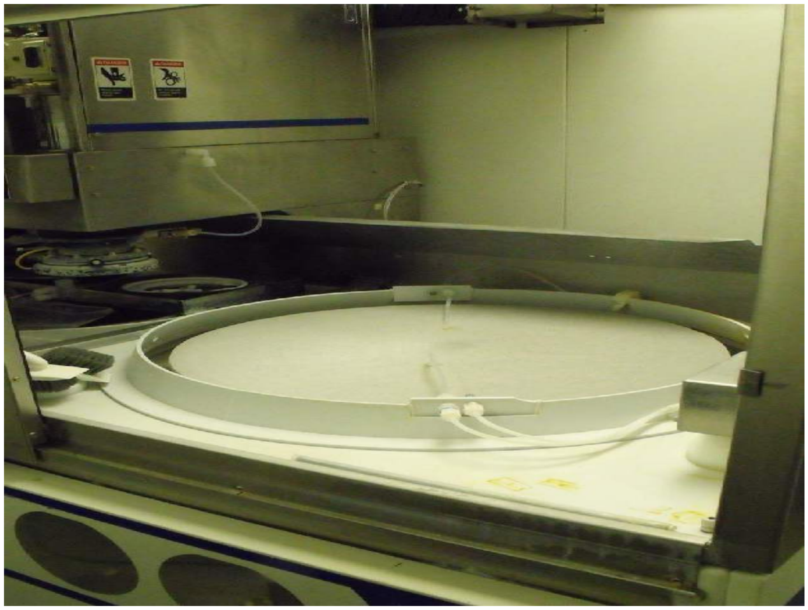
# CONDITIONING ARM DOWN FORCE ASSEMBLY

The servo-controlled conditioning arm down force feature provides programmable down force for the pad conditioning device.

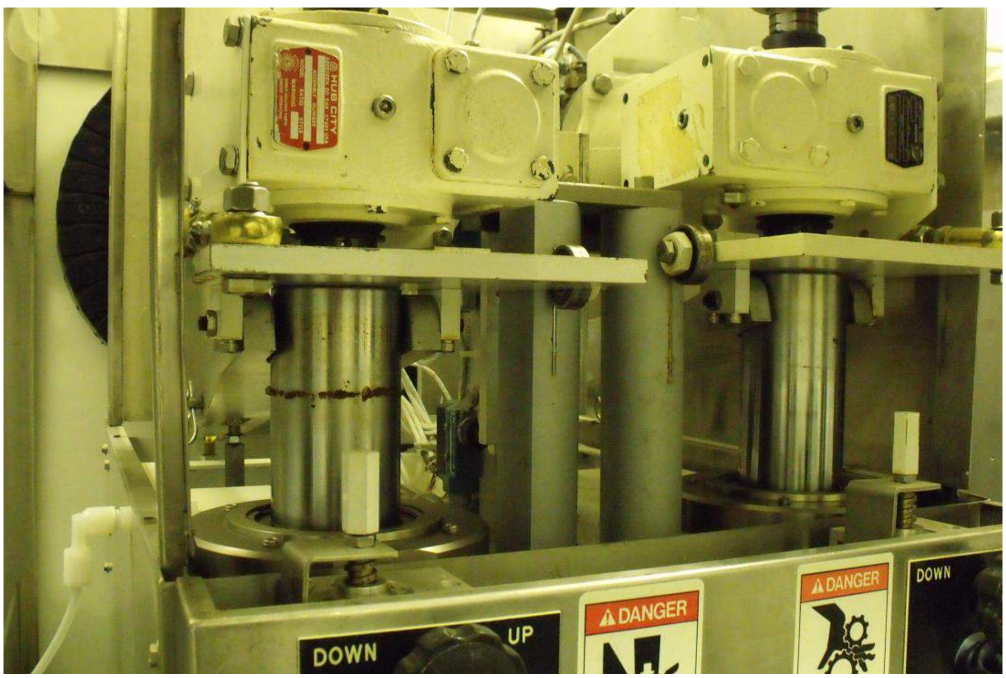
The conditioning arm device assembly consists of a circular rotating device (with programmable rotational speed) which applies a downward force upon the polish table while being driven linearly by a linear drive DC motor from the middle of the polish table to its circumference (or vice versa) for a conditioning cycle. At the end of a cycle, the conditioning assembly parks itself off the polish table to the right. A magnet in the linear drive mechanism homes the arm, using encoder feedback to determine its inner, outer, and park positions. A pneumatic cylinder at the base of the arm assembly shaft raises the entire assembly to move the conditioning device off the polish table or lowers it to apply a regulated downward pressure upon the surface of the polish table. When the arm is at the table, a second air cylinder, together with a load cell and an electro-pneumatic regulator, raises and lowers the device itself, producing and controlling conditioning down force. The second air cylinder's function is programmable in software.

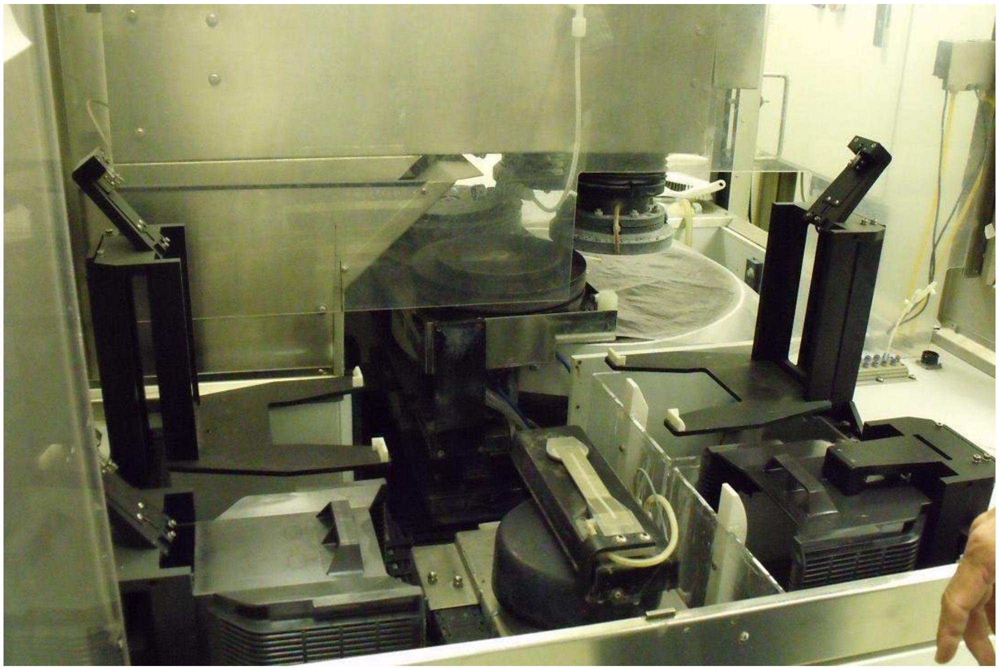
The load cell senses the amount of force applied and generates an analog voltage signal proportional to the amount of force. This signal is amplified and transmitted to the control computer through an analog input channel. The control computer receives the information and compares it to the programmed value of required device down force. The control computer regulates the applied force by regulating the air flow to the air cylinder with the electro-pneumatic regulator. The control computer generates an analog voltage signal for the electro-pneumatic regulator, and the regulator adjusts the air pressure in proportion to the voltage level of the signal. Together the control computer, load cell, and electro-pneumatic regulator form a closed loop controller to maintain the downward conditioning force within 2% of the programmed force value in pressure mode.

The programmable functions of the conditioning arm are controlled at the Sweep Parameters and Conditioning/Cleaning Parameters Menus.




DOWN
UP
SPINDLE STOP
DANGER
Pinch points. Watch your hands.
DANGER
Do not operate without guards in place.
DOWN
SPINDLE STOP


DANGER
DANGER
DOWN
DOWN
UP



P