SURFSCAN 4500

TENCOR INSTRUMENTS

FOR CLEAN-ROOM USE CLASS 100 ONLY

087815 REV. C 6/87

2400 Charleston Road, Mountain View, CA 94043
Phone: (415) 969-6767 TWX: 910-379-6436 FAX: 415-969-6371

Warranty

Except as otherwise indicated, Tencor Instruments warrants to the Buyer that the items sold by it hereunder are free from defects in material and workmanship and meet applicable specifications. In discharge of this warranty, Tencor Instruments agrees either to repair or replace as it may elect, any part or parts which under proper and normal use prove(s) defective in material or workmanship within 12 months after delivery to Buyer. If it is recognized that some components and accessories fail to give reasonable service within a reasonable period of time, as determined solely by Tencor Instruments, Tencor Instruments will at its election replace or repair them. Tencor Instruments may at any time discharge its warranty as to any item by refunding the purchase price and taking back the item.

Unless the Buyer shall inspect all items and within 30 days of delivery notify Tencor Instruments of any apparent defects discovered and shall return the apparently defective item, transportation charges prepaid, to Tencor Instruments' factory or service office if so directed, Tencor Instruments shall have no liability hereunder.

The foregoing warranty and remedy are exclusive and Tencor Instruments shall have no other liability under any other warranty express or implied either in fact or by operation of law, statutory or otherwise. Tencor Instruments shall have no liability for special or consequential damages of any kind and from any cause arising out of the installation or use of any item.

Copyright

Trademarks

Surfscan is a trademark of Tencor Instruments. Fluoroware is a trademark of Fluoroware, Inc. Digitec is a trademark of DIGITEC, Dayton, Ohio. Epson is a trademark of Epson America. Okidata is a trademark of Oki America, Inc. Centronics is a trademark of Data Computer Corporation.

Operating Safety

This system contains a helium-neon laser rated for 2 milliwatts with an effective operating power of 0.2 milliwatts. A safety interlock is provided on the laser scan circuit that will automatically turn off the laser if the scanning mirror fails to operate. Do not defeat the function of this safety feature.

Use of controls or adjustments, or performance of procedures other than those specified herein may result in hazardous light exposure. Caution labels located on both sides of the scan unit cover are reminders of laser hazards.

Pursuant to the Regulations for the Administration and Enforcement of the Radiological Control for Health and Safety Act of 1968 (pertinent to laser products), a document describing this product has been filed with the Consumer Industrial Products Branch (HFZ - 312) of the Division of Radiological Products of the National Center for Devices and Radiological Health (CDRH). This product conforms to the requirements for a Class I Laser product.

High Voltage

This system contains components requiring high voltage (between 500 and 1500 VDC).

CONTENTS

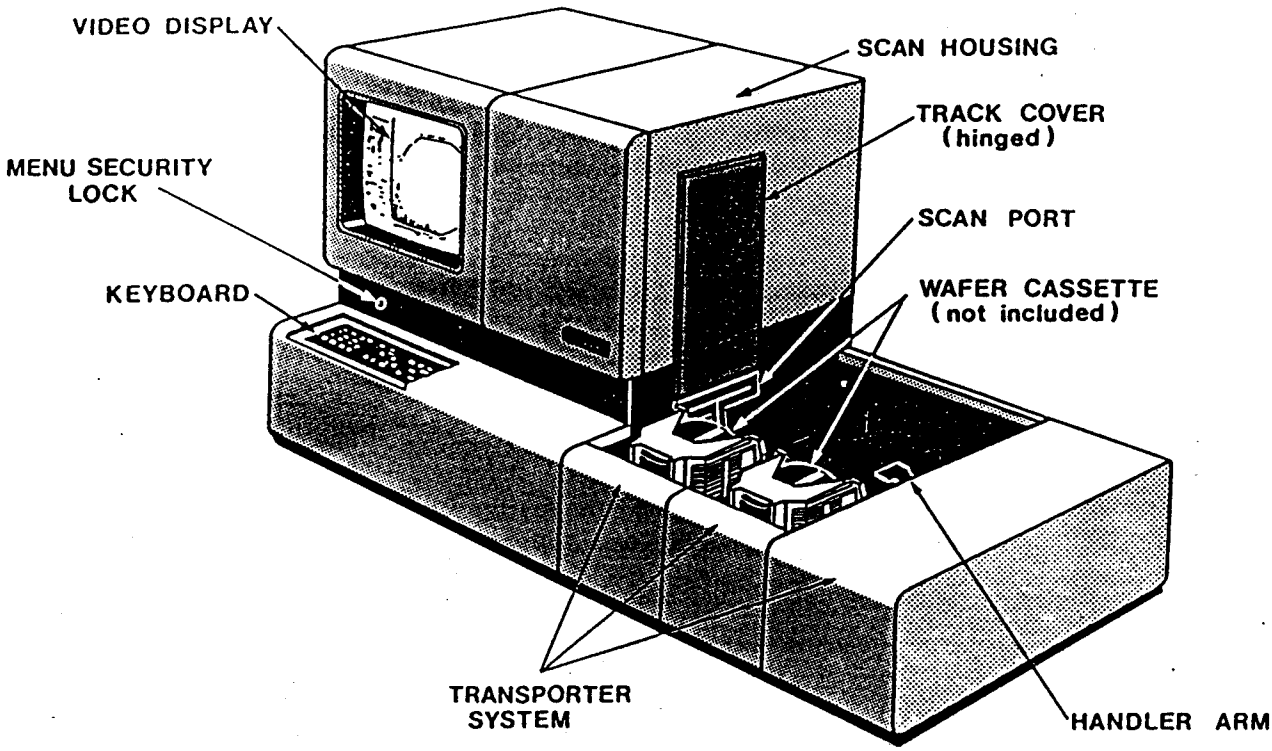

Figure 1: Surfscan 4500 Components

FIGURES

SECTION 1 -- INTRODUCTION

The Surfscan 4500 measures the size, number, and location of wafer particles with scattering cross-sections from .006 μm^2 to 1024 μm^2. It features a robotic substrate transporter and optional indexer configurations.

After fetching the wafer, the puck transports it inside the scan housing for measurement. Data appears on the monitor as the scan progresses. When the scan is complete, the puck returns the scanned wafer to the receiver cassette.

1.1 FEATURES

The Surfscan* 4500 has the following features:

Submicron Sensitivity

System sensitivity, measured with latex spheres on a bare silicon wafer, is 0.2 μm diameter.

Non—Contaminating Wafer Transport

Robotic handler with vacuum puck eliminates contamination associated with belt handling.

High Efficiency Elliptical Mirror Light Detection

Patented elliptical mirror detection system maximizes the collection of scattered light while minimizing noise from background light.

Fully Digital Signal Processing

High-speed digital signal processing (16 MHz) produces Particle Maps, Histograms, and Haze Maps with X-Y particle addressing and 8-bit-size resolution.

*U.S PATENT NO. 4,378,159

Menu—Driven Operation

Color-keyed data, help, and set-up screens simplify operation.

Automatic Calibration

An internal scattering standard is monitored through a closed-loop feedback system to compensate for effects of photomultiplier drift, laser aging, and other long-term circuit drifts. System calibration is maintained 400 times per second.

Automatic Zeroing

A zero-scattering standard is referenced after each laser scan to ensure that measurements are independent of ambient light level.

Overload Protection

The photomultiplier is automatically disabled whenever the scattered or ambient light level exceeds detector limits. This prevents overload damage and invalid readings.

Pulse Position Correlator

Enables particle counting classification to determine particle count with high precision. The PPC also allows Area Zoom capability.

HEPA Filter System Purging

Purifies air entering the instrument by removing airborne particles.

Optional Cassette Configurations

Two Surfscan 4500 configurations may be ordered. The indexer adjacent to the scan housing holds sender cassettes of wafers to be measured. When loaded on the indexer, the cassette loads a switch, signaling its presence.

1.2 SPECIFICATIONS

MEASURABLE MATERIALS AND RANGES

Substrate Diameter

2-inch, 3-inch, 100 mm, 125 mm, and 150 mm .

Substrate Thickness

SEMI standard wafer thickness.

Material Type

In the most sensitive range, any opaque, polished surface that scatters less than 0.025% of incident collimated light averaged over the substrate. In the least sensitive range, any surface that scatters less than 10% of incident light.

Particle Sensitivity

0.2 μm diameter latex spheres on bare silicon substrate. (This corresponds to approximately 0.015 μm^2 light-scattering cross-sectional area.)

Haze Sensitivity

0.4 parts per million with 0.1 ppm increments.

Spatial Resolution

Minimum spacing of 50 μm between particles.

Particle Range

The MAX SIZE values are [μm^2]: .256, .512, 1.024, 2.56, 5.12, 10.24, 25.6, 51.2, 102.4, 256, 512, 1024

Count Accuracy

Better than 1%, as measured on a VLSI Standard's relative standard.

Repeatability

Particle counts repeatable to 1% or less, independent of wafer orientation. (Mean count of 500 particles, 1 μm diameter latex spheres.)

Contamination

No more than two particles with scattering cross-section greater than 0.5 μm^2 per 50 passes. (with 97% confidence).

MEASUREMENT SPEED AND THROUGHPUT

Scanning Beam

Cycle of 400 laser scans per second.

Light Source

Helium-neon laser; 2mW; wavelength (λ) = 6328 Å.

Substrate Speed

During scanning, forward motion at a rate of 10 mm/second.

Throughput

For a 100 mm wafer, fetch-measure-unload cycle, 50 seconds.

OPERATING MODES

The Surfscan 4500 can be operated in two modes: *manual* or *auto*

Automatic Mode

Automatic Mode automatically subjects all wafers in a cassette to same parameter values. This is used primarily with cassette-to-ca handling and sorting of 3-inch, 100 mm (4-inch), 125 mm (5-inch), 150 mm (6-inch) wafers.

Manual Mode

Manual mode facilitates detailed analysis of individual wafers fro cassette. This is used primarily for cassette-to-cassette handling c same substrates as Automatic Mode; however, each scan must be initiated separately.

DATA OUTPUT

High Resolution Color Monitor

Parallel Data Output Port
Parallel interface to either the 80-column or 20-column printer.

Serial Data Output Port
For dual 20/80-column printer operation, check with Tencor Instruments for proper cabling and configuration.

External Printer
Okidata 292, Epson FX-85 and Citizen HSP-350 80-column printers and Digitec 20-column alphanumeric printers are supported.

External 80—column printers should contain a minimum of 32K of buffer RAM. Printers with less than 32K RAM may slow system performance.

ELECTRICAL POWER

Voltage

The Surfscan 4500 must be operated at the voltage selected at the AC voltage selector. Refer to the procedure in *Maintenance* when changing voltages.

100 VAC ± 10%, 50 OR 60 Hz.
117 VAC ± 10%, 60 Hz.
220 VAC ± 10%, 50 Hz.
240 VAC ± 10%, 50 Hz.

Power Demand

- Surfscan 4500: Single-phase only; 350 VA.
- Printer: Single-phase only; 28 VA.

Power Quality

If the utility power source has radio-frequency interference, an isolation transformer may be necessary to provide additional filtering. Sensitive Surfscan processor components require power which is free from spikes, dips, and surges.

FUSES

Scan Unit Fuses

For **100 VAC** or **117 VAC**, 5 Ampere slow-blow.

For **220 VAC** or **240 VAC**, 2 Ampere slow-blow.

These fuses are time-lag, slow-breaking capacity. Replacements equivalent to Schurter 034.3124 (5 A) or 034.3120 (2 A) may be ordered from Tencor Instruments.

Monitor Outlet Fuse

For **117 VAC** only: 2 Ampere 117 VAC slow-blow. (Fuseholder located on monitor shelf.)

Printer Outlet Fuse

For 117 VAC only: 1 ampere 117 VAC slow-blow. Fuseholder is located on the Power I/O Panel.

Printer Internal Fuse

For **117 VAC (110-117)**: 1/4 Ampere 125 VAC slow-blow.

OPERATING ENVIRONMENT

Temperature

Normal operating temperature should be between 18 and 22 degrees Celsius (64 to 72 degrees Fahrenheit).

Air Quality

The Surfscan 4500 should be operated in a Class 100 or cleaner environment.

When operating the Surfscan 4500 outside of a clean room environment, THE HEPA FILTER MUST BE ON AT ALL TIMES. The optical scanning mirror will be damaged by environmental dust if the HEPA filter is not ON during non–cleanroom use. The message window indicates whether the HEPA filter has been toggled ON.

Room Lighting

Scan unit components are extremely sensitive to outside light. The Auto-Zero feature of the detection system compensates for normal amounts of overhead illumination; however, excessive lighting may affect measurement.

Under no circumstances should direct light enter the scan port – this raises the dark noise level of the Photomultiplier Tube, decreases sensitivity and may result in permanent damage to the PMT.

Vacuum

The transport system requires a 20-inch Hg vacuum to secure a substrate to the puck during fetching, scanning, and unloading. The vacuum must be clean with no backstreaming to the puck. (Use an in-line filter to prevent contamination from pumps.)

Electro–Magnetic Interference

The Surfscan 4500 should not be operated near heavy emitters of radio-frequency interference (RFI) or in strong electrical or magnetic fields.

Vibration Interference

The Surfscan 4500 should not be operated near sources of vibration, such as fans, motors, or in excessive flow of cleanroom air duct. Equipment should **NOT** be placed on top of the transporter or other parts of the Surfscan 4500 – vibration may be transferred to the measurement optics.

PHYSICAL CHARACTERISTICS

Weight

System: 94 kg (206-pounds).

Scan Unit: 84 kg (184-pounds)

Monitor: 10 kg (22-pounds)

Printer: 1.59 kg (3.5-pounds)

Shipping Weight: 219 kg (482-pounds)

The cleanroom bench must support the weight of the Surfscan 4500 without sagging. Except for the pedestal feet, no other part of the chassis should be touching the cleanroom bench.

Dimensions

Surfscan 4500

127 cm (50-inch) wide x 61 cm (24-inch) deep x 64 cm (25-inch) high

Printer

18.8 cm (7.38-inch) wide x 15.5 cm (6.12-inch) deep x 7.8 cm (3.08-inch) high

Shipping Carton

156 cm (61.5-inch) wide x 84 cm (33-inch) deep x 107 cm (42-inch) high

1.3 INSTALLATION

Please review all specifications before planning site installation.

Planning

Do not unpack the Surfscan 4500 until the installation site is fully prepared. The system is wrapped in plastic to prevent contamination. When facilities meet operating specifications, unpacking can begin.

The carrier is responsible for damage incurred during shipping -- contact the carrier immediately if the unit appears damaged. Retain all damaged shipping crates for inspection.

A plan view of the Surfscan 4500 installation site is illustrated below. The bench surface must be flat, rigid, and provide adequate ventilation beneath the scan unit. Allow space to the left of the scan unit for access to the power switch and fuse holders. Allow 8 to 10 inches behind the Surfscan 4500 to permit adequate clearance for purging with the HEPA Filter.

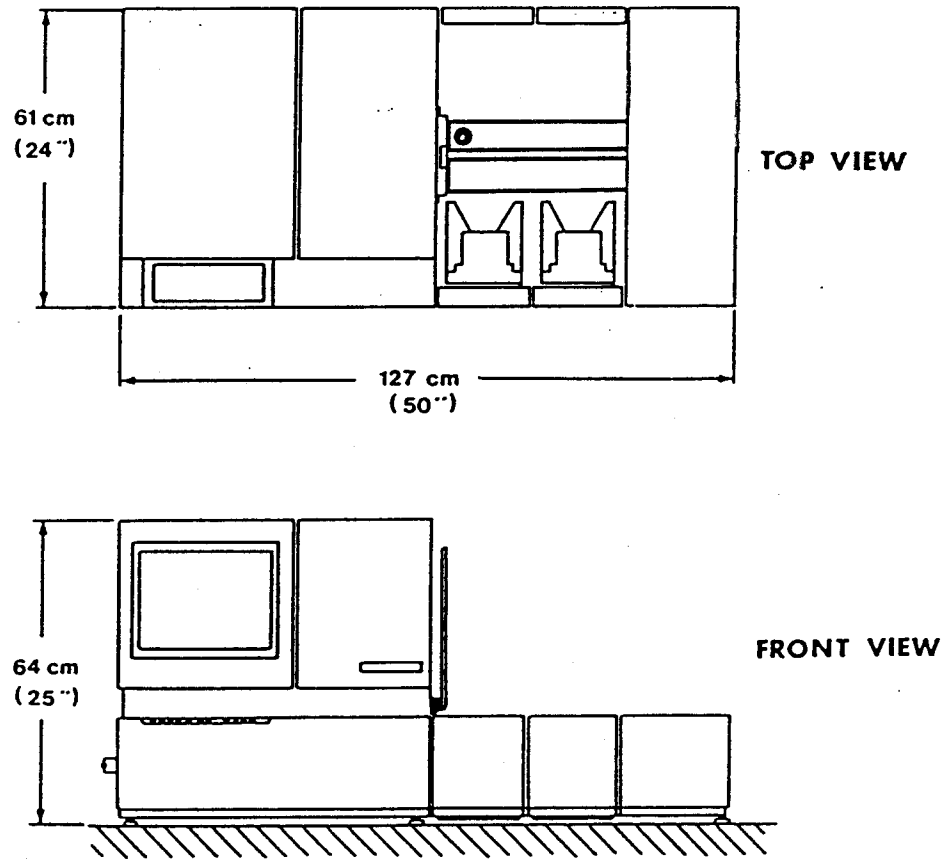

Figure 2: Plan View Installation

Unpacking

Remove the bolts which fasten the bottom edge of the shipping carton and lift the cover straight up. Do not remove the plastic sheeting at this time.

Two or three strong people should assist in lifting the Surfscan 4500 from its crate to a cart for transportation.

DO NOT LIFT THE TRANSPORTER END OF THE SCAN UNIT!
Leverage applied to the transporter segment of the Surfscan 4500 may result in structural damage to important internal supports.

Recommended lifting positions are:

- The *Power Drawer* end of the instrument (optional).
- The center of the instrument, one in front and the other in back.

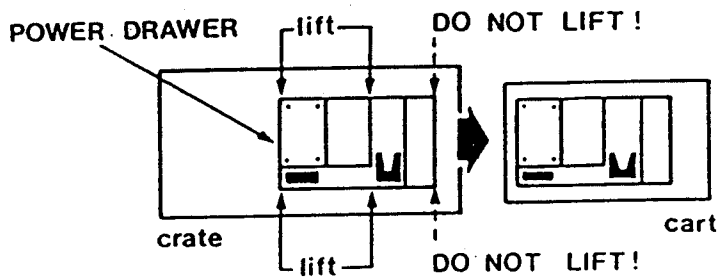

Figure 3: Lifting Positions

Place the Surfscan 4500 on the cart and move it to the cleanroom entrance.

Check the crate for separately packed parts and move these near the cleanroom entrance. These should include:

- Monitor
- 20-column printer
- Monitor signal cable assembly (marked "RGB")
- Printer cable
- Scan Unit power cord
- Monitor power cord
- Two rolls of cleanroom printer paper
- Any accessories ordered with the Surfscan 4500

Save the shipping crate and shipping materials for future transportation of the instrument. The Surfscan 4500 must be shipped in the same container to properly protect its mechanical components.

Wipe the plastic sheeting clean with alcohol and cleanwipes. Remove the plastic and move the cart into the cleanroom. Move the Surfscan 4500 onto the cleanroom bench.

THE SURFSCAN 4500 IS NOT A PORTABLE INSTRUMENT -- DO NOT LEAVE IT ON A CART.

Leveling

The Surfscan 4500 must be leveled before operation. Six pedestal feet raise or lower the instrument until it is level:

❶ Turn feet 5 and 6 clockwise until they are approximately 1/2-inch above the cleanroom bench.

❷ Turn feet 1 and 2 until the bottom of the Surfscan 4500 is 3/4-inch to 1-inch above the cleanroom bench (this insures ventilation through the *Power Drawer*).

❸ Check that 5 and 6 are not touching the bench. If they are, turn them clockwise until they are no longer touching the bench.

❹ Check the bubble level located on the metal rib of the transporter. Level the Surfscan 4500 as much as possible by turning feet 3 and 4.

❺ Raise or lower feet 1, 2, 3, and 4 until the Surfscan 4500 is level (until the bubble is entirely within the black circle). Check that the Surfscan 4500 does not "wobble" between diagonally-positioned feet (e.g. the 1-4 pair or the 2-3 pair).

❻ Turn feet 5 and 6 until they support the weight of the transporter end of the Surfscan 4500. Check the level again.

❼ Unwrap the monitor and place it next to the scan housing above the keyboard. Its feet should set into the small indentations on the Surfscan 4500 cover. Check bubble level again.

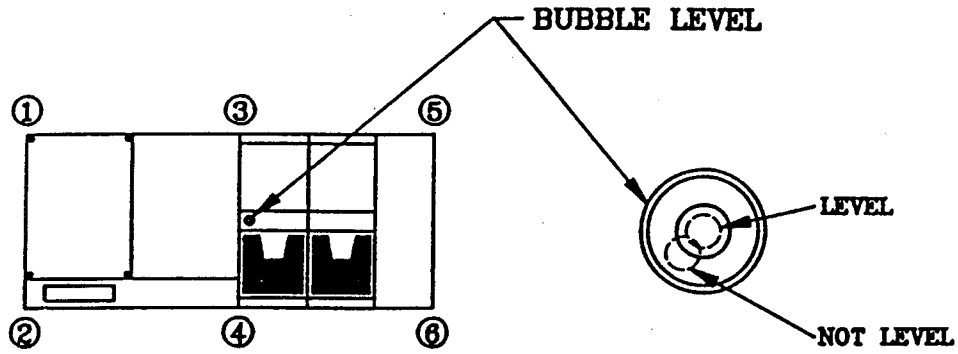

Figure 4: Leveling Feet

Connecting System Reset

The System Reset button attaches to the 25-pin connector (OUT 2) on the left side panel. Tighten the socket head screws to prevent accidental removal.

The power must be OFF (0) when installing or removing system reset button.

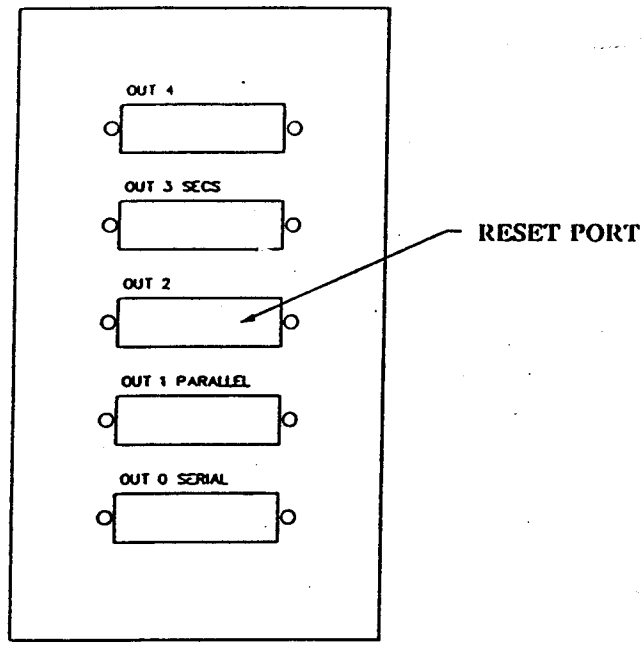

Figure 5: Connecting the System Reset Button

Connecting Cables

❶ Raise the rear access cover of the monitor.

❷ Connect the three coaxial monitor signal cables between the monitor BNC plugs (marked R,G,B) and their respective plugs located at the rear of the top panel of the scan-unit chassis.

❸ Connect the monitor power plug between the monitor power outlet and the receptacle located at the rear of the top panel of the scan-unit chassis.

❹ Unwrap the printer and set it nearby (preferably below the cleanroom bench) within reach of the printer signal cable.

❺ The printer signal cable connects to the parallel output port on the I/O panel.

❻ Connect the printer power plug to the printer power outlet on the *Power Drawer* panel.

❼ Check the voltage shown by the AC voltage selector (on the *Power Drawer* panel, below the power switch). The power receptacle, houses two main fuses and the AC voltage selector. The VAC value shown in he window of the fuse cover must match the utility power.

The Surfscan 4500's utility power is regulated through the *Power Drawer* assembly. In addition to supplying power for the scan unit, the *Power Drawer* provides outlets that regulate voltage to both the monitor and external printer.

The AC voltage selector is not a thumbwheel switch. It is a cam which must be removed, rotated (to select the desired AC voltage), and reinserted. Refer to the procedure in MAINTENANCE to change the selected value if it does not match the voltage delivered by the outlet.

❽ Check that the Surfscan 4500's ON/OFF switch is toward "0" (OFF).

❾ Plug the Surfscan 4500's power cord into the left panel *Power Drawer* receptacle. Plug the other end into an appropriately rated outlet.

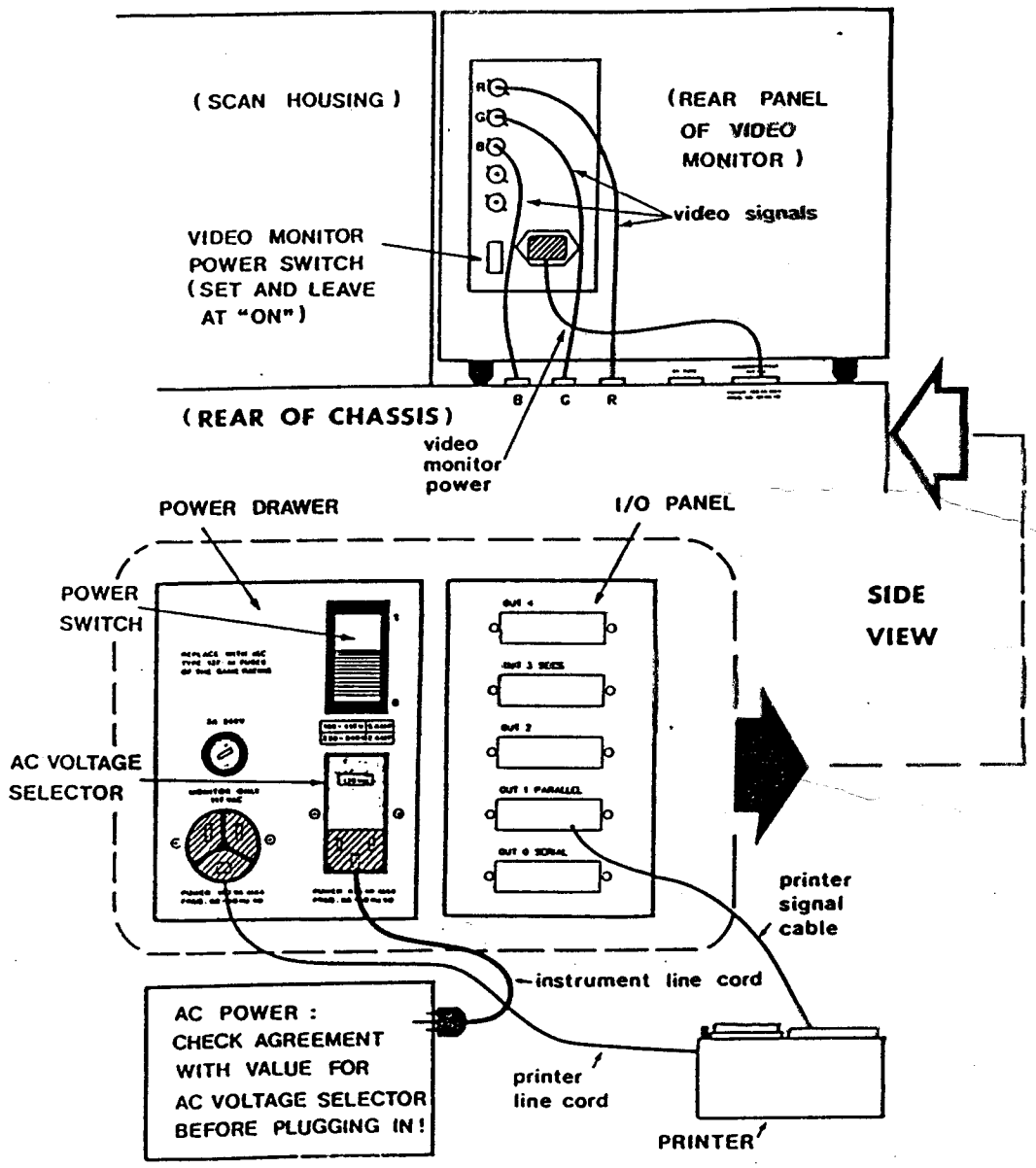

Figure 6: Cable Connection Schematic

Connecting Vacuum

Connect a 1/4 inch vacuum line to the fitting on the right rear of the transport unit chassis. The facilities vacuum must supply at least 20-inch Hg. vacuum to the Surfscan 4500.

Checking Installation

Check the following before powering up:

- Surfscan 4500 is level.
- Monitor signal cable assembly is connected.
- Monitor power cord is connected.
- Printer signal cable is connected.
- Utility power outlet voltage matches AC voltage selector.
- Surfscan 4500 power cord is connected to outlet.
- Printer power cord is connected to the Scan Unit *Power Drawer.*
- Vacuum line is connected.

SECTION 2 – OPERATION

2.1 POWERING UP

The HEPA filtering system MUST BE ACTIVE whenever the Surfscan 4500 is operated outside a cleanroom environment. Severe damage to the optical components can result from operating the Surfscan 4500 outside a cleanroom without the HEPA filter running continuously. The function line of the Data Display will indicate "HEPA" when the fan is toggled *ON*.

When in a cleanroom, it is recommended that the HEPA filter be used to purge the system after moving or servicing.

❶ Plug the printer into the outlet provided on the Power Drawer BEFORE turning on the Surfscan 4500 power switch.

❷ Turn the power switch (located on the left side panel) to "1" (ON). The LED on the keyboard should light, indicating that the system is on. Check to see that the printer is powered up.

Allow the Surfscan 4500 electronic components to "stabilize" for 30 minutes before taking measurements.

❸ Check that the keyboard is active by pressing [MENU].

- If the menu appears, the keyboard is active.
- If pressing [MENU] did not change anything, the keyboard is temporarily locked. To activate the MENU key, turn the security lock counterclockwise. Now press [MENU].
- The monitor should display four Quadrants:
  - Data Collection
  - Data Display
  - System Configuration
  - Sort Parameters.

2.2 CALLING HELP

Help screens provide users with readily accessible information concerning operating instructions and applications. Topics are selected from an outline.

❶ Press [HELP] to display the HELP MENU.

❷ Press [↑], [↓] [→], or [←] to move the cursor to the desired topic.

❸ Press [SEL] to display the selected topic.

❹ To display the next Help Screen, press [→]. To display a previous Help Screen, press [←].

❺ To exit the help function, press [ABT].

2.3 MENU ARCHITECTURE

[MENU] toggles between the DATA DISPLAY and the MENU.

The MENU organizes parameters for data collection, display, instrument configuration, and sorting. Parameters are easily changed to meet research specifications or on-line quality testing. The Security Lock may be used to prevent unauthorized access to MENU parameters. Twenty-five MENUS may be programmed and stored in non-volatile memory (parameter values are maintained even while the power is off).

The DATA DISPLAY shows results of the previous scan in a variety of forms including: Particle Maps, Histograms, Haze Maps, and Summary Data. Displayed information may be output to the parallel printer (Multiple layers must be printed individually).

Screen Saver

The Surfscan 4500 preserves the operating life of its monitor by lapsing into a *screen-saver* mode after several minutes of disuse. If no commands are issued within several minutes, the video screen will blank out. The last screen image is recalled by pressing one of the arrow keys.

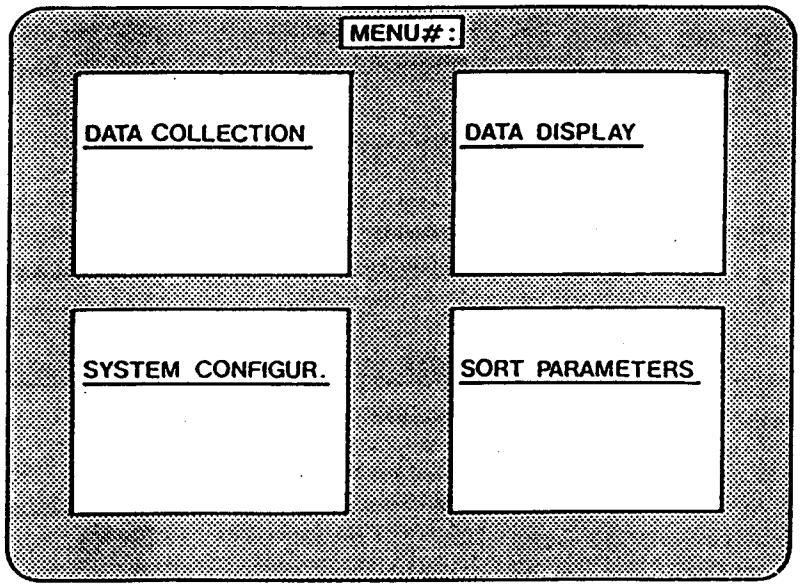

Figure 7: Menu Quadrants

2.4 SETTING MENU PARAMETERS

The MENU consists of four quadrants which list user-programmable parameters:

Data Collection parameters specify how the data is collected.

Data Display parameters define the type and range of data to be displayed.

System Configuration parameters determine transporter and printer configurations.

Sort Parameters determine accept/reject criteria.

[NXT] toggles the cursor between quadrants so parameters can be changed.

As you move the cursor up and down the parameter list, some parameters will display < > beside them, indicating these are *fixed field parameters.* Use [←] or [→] to change the listed parameter values; then use [↑] or [↓] to move to the next desired parameter. Previous values are **not** restored by pressing [ABT].

If the selected parameter **does not have** < > beside it, a new value can be entered via the numeric keypad (Some values will be truncated by the computer). Press [ENT] to enter the new value. Other keys that can enter the new value are: [↑], [↓], [NXT], and [PLT]. The new value is entered and simultaneously stored if [START] or [MENU] is pressed.

If a mistake is made before entering (or entering and storing) the new value, the old one can be restored by pressing [ABT].

DATA COLLECTION PARAMETERS

If Data Collection parameters are changed before a replot command is issued, the MENU displays "`Replot Disabled`" since data has not been collected to the new specifications.

EDGE EXCLUSION

1 to radius of substrate

Sets the width of a strip (measured in millimeters) inside the edge of the wafer where data collection is suppressed. The area within this boundary is the *active wafer surface.* This parameter should be set before setting FRONT EXCLUSION.

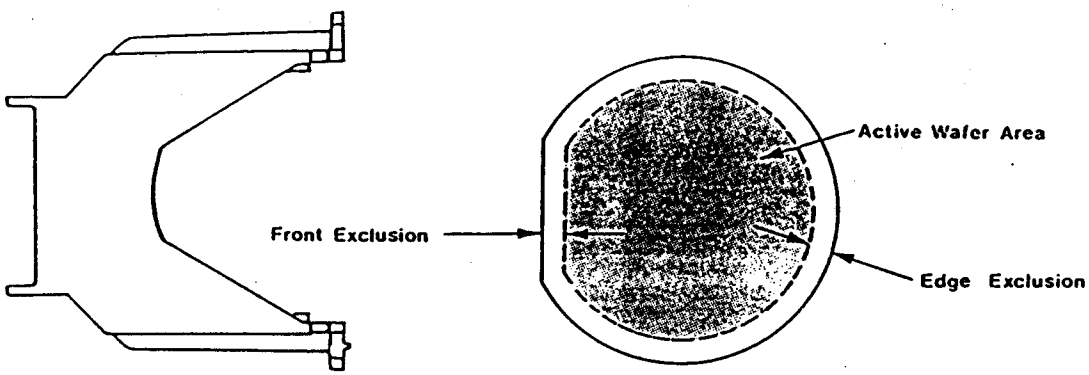

Figure 8: Front Exclusion

FRONT EXCLUSION

1 to diameter of substrate

Sets a vertical boundary with a similar function as edge exclusion. The data collected will not include the substrate area to the left of the FRONT EXCLUSION line. This distance is measured from the edge of the wafer first detected by the scanning beam. (Orient wafers in the sender cassette with the major flat to the rear of the cassette). FRONT EXCLUSION cannot be defined as smaller than EDGE EXCLUSION.

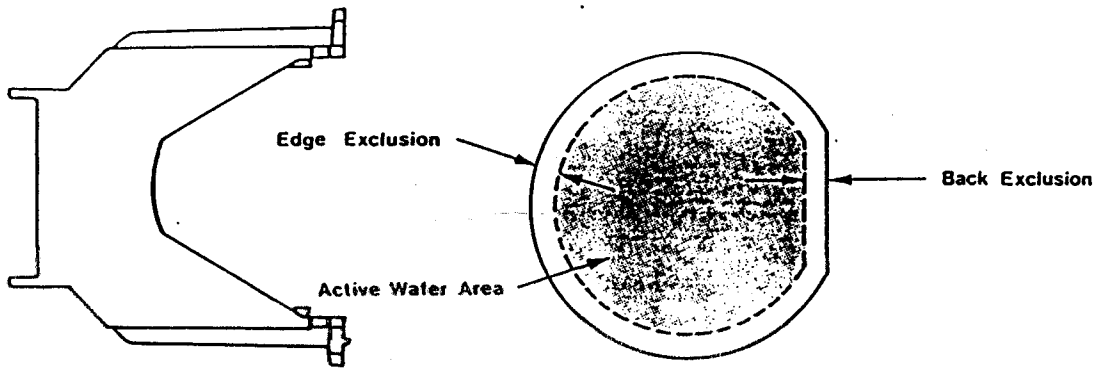

Figure 9: Back Exclusion

BACK EXCLUSION is designed for wafers oriented with their major flats toward the front of the cassette. The BACK EXCLUSION value is measured back from the flat and is entered in the FRONT EXCLUSION parameter field by pressing the minus sign (⊟) before entering the number. Then data is not collected to the right of BACK EXCLUSION boundary.

SUBSTRATE

2 inch
3 inch
100 mm
125 mm
150 mm

Specifies the diameter of the substrate in inches or millimeters.

Because the scanning beam focuses on a plane above the puck determined by wafer size, wafer thickness should not exceed SEMI standards. If the substrate is outside the focal plane, the data will be inaccurate.

MAX SIZE [μm^2]

0.256
0.512
1.024
2.56
5.12
10.24
25.6
51.2
102.4
256.
512.
1024.

The Photomultiplier Tube (PMT) has 12 different sensitivity levels which determine MAX SIZE – the ranges of data collection. Setting the PMT gain for the specific range of interest maximizes resolution since collected data is always divided into 256 groups.

Detecting very small particles requires a high PMT gain. When the smallest range of particles is measured (MAX SIZE = 0.256 μm^2) the PMT gain is 100%.

The MAX SIZE should never be set at less than 1/100 the HAZE AVG. TOTAL value. For unknown wafers, it is useful to set MAX SIZE high and determine the approximate haze from a test scan by reading the value in the Summary Data.

Note: If MAX SIZE is 0.00, the remaining Data Collection parameter values are erased and the PMT is disabled. This is a service mode of the Surfscan and has no relevance for normal application.

THRESHOLD

THRESHOLD determines the minimum level of scattering cross-section the Surfscan will collect, but not necessarily display. (See discussion of scattering cross section in *Theory of Operation.*)

DATA CORRELATION (PPC)

SINGLE or DOUBLE

The Summary Data shows which value is selected with an "s" for SINGLE or a "d" for DOUBLE after the word "THRESHOLD." When in double mode, the PPC requires two threshold peaks to score a hit. When in single mode, the PPC will classify everything that exceeds the THRESHOLD as a "hit".

The value DOUBLE reduces the influence of background noise on measurements.

MAX HAZE (ppm)

Calculated from the value of the MAX SIZE, this value is always 100 times greater than the MAX SIZE value. The parts per million (ppm) value relates to the maximum level of scattered light measurable at the given MAX SIZE.

DYNAMIC RANGE

The Dynamic Range is the calculated percentage of MAX SIZE remaining after subtracting THRESHOLD. Dynamic range cannot be changed except by changing MAX SIZE or THRESHOLD.

DATA DISPLAY PARAMETERS

The Data Display can show measurement results in three modes: *Composite mode, Particle mode* **or** *Haze mode.*

The value COMPOS, *(Composite Mode)*, selects a display containing any combination of a Particle Map (toggled by [YELLOW]), Histogram (toggled by [ORANGE]), and Haze Map (toggled by [BLUE]).

The value PARTICLE, *(Particle Mode)* selects the Three-Color Particle Map (smallest particles in yellow, medium particles in orange, and largest particles in blue) for replotting.

The value HAZE (*Haze Mode*) selects the seven-level Haze Map for replotting.

The display mode can be changed before or after a scan. For example, if you have the Particle Map and Histogram on the Data Display, you could change the DISPLAY MODE parameter to PARTICLE and replot to view the Three-Color Particle Map. *Tencor Instruments intends the Particle and Haze Modes to be used for replotting data only; all wafer scans should be done in Composite Mode only.*

Composite Mode

PARTICLES FROM/TO

Defines a subset of the collected data for plotting or replotting. Boundaries cannot exceed the following values for THRESHOLD or MAX SIZE, and depends on the DATA CORRELATION setting.

In SINGLE mode: 1 x Threshold to Max. Particle Size

In DOUBLE mode: 1.5 x Threshold to Max. Particle Size

HISTOGRAM TYPE

Indicates that particles are counted and classified with a Pulse Position Correlator (PPC).

HISTOGRAM BIN

Defines the width of each orange bar in the Histogram of Data Display. This width relates to the resolution available at the range (MAX SIZE) of Data Collection. To set the default bin width to the smallest possible for any range, enter the value 0 (zero). If there are many small spikes in your histogram, it is often beneficial to average them by increasing the width of histogram bars.

HAZE FROM/TO

Defines a subset of the collected data for plotting or replotting. Boundaries cannot exceed the values calculated for MAX HAZE depend on MAX SIZE.

Particle Mode

YELLOW FROM/TO

Defines a subset of the collected particle data to be replotted in yellow on the three-color Map. YELLOW FROM cannot be less than the THRESHOLD (Data Collection quadrant). The value for YELLOW TO cannot exceed the value for ORANGE FROM.

ORANGE FROM/TO

Defines a subset of the collected particle data to be replotted in orange on the Three-Color Particle Map. ORANGE FROM cannot be less than the value for YELLOW TO. The value for ORANGE TO cannot exceed the value for BLUE FROM.

BLUE FROM/TO

Defines a subset of the collected particle data to be replotted in blue on the Three-Color Particle Map. BLUE FROM cannot be less than the value for ORANGE TO. The value for BLUE TO cannot exceed the MAX SIZE (Data Collection quadrant).

Haze Mode

HAZE FROM/TO

Defines a subset of the collected data for replotting. Boundaries cannot exceed the values calculated for MAX HAZE, dependent on MAX SIZE. The HAZE FROM/TO range is divided into seven bins and each bin is assigned one shade of blue (the darker the blue, the brighter the reflected component). Everything outside of this range is black. Note: [YELLOW] and [ORANGE] are disabled in HAZE mode.

SORT PARAMETERS

Sort parameters apply only to the active wafer area. These parameters serve as criteria to accept or reject scanned substrates. Measured wafer values must pass all Sorting Parameter values to be accepted. The wafer also may be rejected if certain scanning error messages appear in the message window (read "Interpreting message window"). "ACCEPT" or "REJECT" is placed in the Summary Data and printed as part of the permanent record.

SYSTEM CONFIGURATION

PRINTER OUTPUT

Selects the form of printer output.

- YELLOW prints the yellow overlay of the Data Display and the Summary Data.
- ORANGE prints the orange overlay and the Summary Data.
- BLUE prints the blue overlay and the Summary Data.
- HISTBL prints a numerical table of the bin sizes versus the number of particles in each bin.
- SUMMARY sends all the Summary Data to the printer.
- SHORT prints only part of the Summary Data.

PRINTER TYPE

20 COL or 80 COL

Selects output format. A value of 20 COL allows only SUMMARY or SHORT printouts. A value of 80 COL selects the output format for a graphics printer.

AUTOPRINT

ON or OFF

When ON, this function triggers an automatic printout after each scan. It is useful for speed processing in *Automatic Mode*. When Autoprint is OFF, printouts may be requested manually by pressing [PRINT] for each desired screen.

TRANSFER MODE

SINGLE: Wafers are fetched from and returned to the sender cassette.

MULTI: Wafers are fetched from the sender cassette and delivered to the receiver cassette (or cassettes, if the instrument has the Three-indexer configuration).

1WFR: A single wafer is manually loaded and scanned. No cassette may be used. Particularly useful when analyzing irregularly shaped (or broken) substrates. The scanner will analyze any substrate shapes up to a maximum of 150 mm across the longest span.

CASSETTE TILT

ON or OFF

Specifies a function of the indexer platform. When ON, the indexer platform tilts back after returning to the top position. When OFF, it does not tilt after returning to the top. (The recommended setting is ON to help keep wafers correctly seated in cassette slots.) OFF should only be used in special circumstances, such as with robotic cassette handling.

SUBSTRATE

Selects some examples of typical substrates for which the correlation of scattering cross section [μm^2] and diameter [μm] was determined for latex spheres:

WAFER	NO SIZE CORRELATION REQUESTED
TYPE-A	Polished silicon
TYPE-B	Silicon dioxide, 380Å on silicon
TYPE-C	Silicon dioxide, 1080Å on silicon
TYPE-D	Silicon dioxide, 2160Å on silicon
TYPE-E	Silicon dioxide, 4320Å on silicon
TYPE-F	Silicon nitride, 825Å on silicon
TYPE-G	Silicon nitride, 1400Å on silicon
TYPE-H	Evaporated aluminum, 1500Å

STATUS DISPLAY

ON/OFF/TEST

Used for diagnostics. When set to ON status, codes appear on the Data Display. This is not useful during normal operation. TEST is for Tencor field service use only. Leave it in the OFF position for general measurements. See *Maintenance* for explanation of troubleshooting.

2.5 PROGRAMMING MENUS

CHANGING MENU NUMBER

The MENU Number can be changed as follows whenever the MENU is displayed:

1. Press [#].
2. Press the numbers (two digits from 01 to 25) of the desired MENU. The MENU will be displayed and the parameters will apply to subsequent scans.

Note: Single digit menus may be retrieved by pressing [ENT] after the digit. For example, if the MENU# field says "03", and MENU number 7 is the one that applies to the next batch of wafers, press either [#] [0] [7] or [#] [7] [ENT] to change the menu.

25 MENUS can be stored in non-volatile memory. Once active, a MENU's parameters can be changed as necessary.

SECURING MENUS

The battery-backed CMOS memory for storing the MENUS will be updated with the parameter values whenever:

- The MENU Number is changed with [#]
- The MENU is turned off with [MENU]
- Scanning is started with [START]

The MENU security lock (located above the keyboard) can be used to prevent changing of MENU parameters. When disabled, [MENU] can be used to change MENU numbers, but not to alter MENUS. When it is necessary to change parameters, [MENU] can be activated by turning the MENU Security Lock counterclockwise.

Press [PRINT] to print the displayed MENU.

2.6 ENTERING DATA ID#

The ID# can be used to identify a cassette (when in *Manual Mode* or *Automatic Mode*) or a single wafer (when in *One-Wafer mode*). Allowable characters for the ID# are numbers, letters, spaces (use [PLT] to indicate a space), dashes (—), #, or decimals (.). Select alpha characters using [↓] or [↑] and [SEL].

If necessary, press [ABT] to restore previous value.

The ID# can be changed at any time within the Data Display.

1. Press [#]
2. Use [←] or [→] to move to desired ID# field.
3. Type the new ID#. If necessary, press [ABT] to restore previous value.
4. Press [ENT] to store changes.

Printouts will display the ID# at the top of the Summary Data.

If the cassette is initialized, the number *after* the asterisk corresponds to the number of the cassette's wafer slot, making the entire ID# identify the specific cassette and wafer.

If the cassette is not initialized, the number after the asterisk is not related to the slot number.

If scanning in One-Wafer mode, the number shown after the asterisk defaults to 0.

2.7 INTERPRETING DATA

INTERPRETING COMPOSITE MODE

When in Composite mode, the Data Display shows the Particle Map in yellow, the Histogram in orange, and the Haze Map in blue. Scan data can be replotted by positioning the Histogram cursors or by changing FROM/TO in the Data Display quadrant.

Any or all of the three color overlays (Particle Map, Histogram, and Haze Map) can be toggled on or off with their respective color keys.

Only one color overlay at a time can be printed by an 80-column printer. The overlay which will be printed is shown highlighted in the Functions Line and can be toggled with the color keys.

Summary Data

A numerical interpretation of the collected and displayed data can be printed on the 20-column printer or an 80-column printer. The Summary Data is updated whenever replotting is done or the Histogram cursors are moved.

The left side of the Data Display always displays the *Summary Data* – even if all color overlays are toggled off. Summary Data includes:

PARTICLES TOT

The number of particles measured within the range set by the Data Display parameters PARTICLES FROM and PARTICLES TO (not the Data Collection Parameters THRESHOLD to MAX SIZE).

PARTICLES/cm^2

The particle density is the number of particles per square centimeter of active wafer area. Active wafer area is the region within the exclusion boundaries.

AREA

Particles longer than 250 µm are classified as *area* and are not counted as particles. Instead, the data is converted to an area value and the substrate's total of area calculated in square millimeters.

HAZE AVERAGE TOTAL (PPM)

This indicates the total integrated scatter and can be used to determine whether the Surfscan 4500 is being operated at the correct PMT sensitivity.

HAZE REGION

The percentage of active wafer area covered by the limits set by HAZE FROM and HAZE TO. Displayed in blue by Haze Map.

SUMMARY HISTOGRAM

The distribution of particles shown between the two Histogram cursors. Up to 11 lines may be given, depending on the range of particles displayed. Since the bins have finite width, divisions may not be even, requiring the last line to catch the remainder. Summary Histogram can be printed using the 20-column or 80-column printer. (HISTBL and Histogram require an 80-column printer.)

The Summary Histogram is automatically updated to include only the data between the Histogram cursors. If the Histogram cursors are moved and [PLT] is pressed, a new Histogram and the corresponding Particle Map are plotted, and the entire Summary Data is updated to summarize the new range. (To return the display to the settings of the Data Display parameters, press [ABT].)

This table has two columns, one for "range", another for "number". The range combines bins and redisplays the Histogram overlay. The number of particles within that group of bins also is displayed.

MEAN AND STANDARD DEVIATION

The *Mean* value is the mean size of the particles of the Histogram. Standard Deviation describes the distribution around the Mean.

These describe mathematically the Summary Histogram (the region between the Histogram cursors). Applications include rapid measurement of mean particle size when a peak exists in the Histogram, such as when conducting a process check or when verifying Surfscan 4500 calibration by scanning a Calibration Standard.

PARAMETER VALUES

Values for the Data Collection and Data Display. These indicate the conditions for the collection and display of the Summary Data. (This is absolutely necessary when printouts have been made, since the MENU cannot always be retrieved to check the values.)

In addition to showing the value for the THRESHOLD parameter, THRESHOLD indicates which type of data correlation was used while collecting data. If DATA CORRELATION = SINGLE, an "s" is displayed. If DATA CORRELATION = DOUBLE, a "d" is displayed.

PARTICLE MAP

Shown in yellow are the positions of particles in the range between PARTICLES FROM and PARTICLES TO.

To analyze rapidly the Particle Map, move the Histogram cursors (with [←] or [→]) to the desired boundaries of the Histogram and press [PLT] to replot. By replotting, the new Particle Map shows particles contained within the particle range between the Histogram cursors.

The Particle Map is toggled with [YELLOW]. It shows the outline of the wafer around the "edge exclusion" zone. The remaining area is called the *active wafer area*. The position of particles in the size range between the PARTICLES FROM and PARTICLES TO parameter values are shown as yellow display pixels in the active wafer area.

HISTOGRAM

The Histogram display is toggled with the [ORANGE] key. It is a vertical-bar distribution curve of the number of particles in discrete size bins. The particle size (horizontal axis) is divided into bins for the specified range. Bin width (range) is determined in the DATA DISPLAY MENU by HISTOGRAM BIN. The number of particles in each bin is plotted vertically and automatically scaled for the most useful Histogram.

Horizontal range is defined with the Data Display parameters or the Histogram cursors.

The minimum bin width depends on the resolution of the Data Collection range. Since there are 256 discrete values measured within each Data Collection range, the minimum bin width is 1/256 of the current range.

For example, for the largest range (Data Collection parameter MAX SIZE = 1024 μm^2), the minimum bin width is 4μm^2. The minimum bin width decreases as the Data Collection range decreases.

Changing the values for Data Display parameters PARTICLES FROM or PARTICLES TO does not change the actual bin width but does affect the displayed width on the Histogram.

HISTOGRAM CURSORS

The Histogram cursors are two dashed white vertical bars on the orange Histogram. They can be moved to analyze the Histogram and Particle Map. The Summary Histogram uses the region between the Histogram cursors for its data set. When the Histogram cursors are moved, the Summary Histogram is automatically updated. Additionally, the Particle Map, Histogram, and the remainder of the Summary Data can be replotted to display data within the boundaries determined by the Histogram cursors.

1. Press [SEL] to toggle between Histogram cursors. The horizontal bar below the cursor indicates it is selected.
2. Use [←] or [→] to move the selected Histogram cursor.

   Note: The minimum spacing between these Histogram cursors is equal to the current bin width.
3. Replot the Histogram by pressing [PLT].
4. To return the Histogram cursors and the Data Display to the original setting, press [ABT]. (The Histogram must be displayed for [ABT] to erase replotting.)

HAZE MAP

The Haze Map is similar to the Particle Map, except it shows the position of Haze instead of particles. Haze Map pixels are 4 times the size of Particle Map pixels and displayed in blue. Changing the values of Data Display parameters HAZE FROM or HAZE TO affects the Haze Map when replotted. The Histogram cursors do not affect Haze Map display or replotting.

AREA MAP

The Area Map shows AREA plotted in white.

❶ Toggle the Particle Map ON. The Histogram must be OFF. (It does not matter whether the Haze Map is ON or OFF.)

❷ Press [PLT]. The Area will be plotted in white.

❸ Keys that erase Area: [ABT], [MENU], [HELP], [ORANGE], [NXT] and [START].

ZOOM

Area Zoom provides 16x magnification of any region of the Particle Map. Summary Data displays data for the plotted area.

❶ Set DISPLAY MODE = COMPOS.

❷ Toggle the Particle Map ON. The Histogram must be OFF. (It does not matter whether the Haze Map is ON or OFF.)

❸ Press [SEL] to display the Area Zoom Square on the Particle Map.

❹ The Area Zoom square is controlled using [↑], [↓], [←], or [→]. Pressing and holding the keys accelerates the motion of the square. If there is only one particle within the Zoom square, its size and position are displayed in the Summary Data Area.

❺ When the square is positioned over the desired area, press [PLT] or [BLUE] key. After the zoomed area has been plotted, the cursor is placed on the first particle and information about that particle is displayed in Summary. The cursor can be moved from particle to particle using the four arrow keys. Note that the edge exclusion appears almost like particles on the Zoom display. However, it is clearly differentiated from particles by the fact that you cannot measure it.

❻ The [ORANGE] key toggles the orange Histogram ON for the size versus count distribution of the Area Zoom particles. [YELLOW] toggles the Particle Map ON, redisplaying the Particle Map with the Area Zoom Square. To redisplay the previous Area Zoom, toggle the [BLUE] key.

❼ Switch between zoom and the previous display using [YELLOW] and [BLUE] respectively.

❽ Press [ABT] to exit Area Zoom.

INTERPRETING PARTICLE MODE

When DISPLAY MODE = PARTICLE, the Data Display, when replotted, shows the Three-Color Particle Map (use *Composite Mode* for the Particle Map, Histogram, and Haze Map). The Data Display parameter values define the ranges for each color, requiring a specific set of parameters in the Data Display quadrant.

The same data plotted as a yellow Particle Map in *Composite Mode* can be replotted in three colors in *Particle Mode*. Each color represents a particle size range and is toggled with the corresponding color key. Yellow is the range for the smallest particles, orange for the middle range, and blue for the largest particles.

Ranges for display can be set with the Data Display parameters while in *Particle Mode*, or with the Histogram cursors in *Composite Mode*.

Data Display parameter values can be changed after scanning. Replotting can be done by pressing [PLT] after changing the values.

If the Histogram cursors are positioned while in *Composite Mode* and the mode is changed to *Particle Mode* without any other changes, the Three-Color Particle Map can be plotted without specifying Data Display parameter values. The portion of the Histogram to the left of the left-hand Histogram cursor is plotted on yellow on the Three-Color Particle Map; the portion between the Histogram cursors is plotted in orange, and the remaining right-hand portion is plotted in blue.

The values for the three bin sizes (YELLOW, ORANGE, BLUE) are displayed in the Summary Data area as well as TOTAL (the sum of particles from the other three ranges).

This mode is for replotting only, not for scanning. Wafer scans should be done in Composite Mode only.

INTERPRETING HAZE MODE

When DISPLAY MODE = HAZE, the Data Display, when replotted, shows the seven-level Haze Map. The Data Display parameter values define the distribution of the different shades of blue. If only a few shades are shown, one can change the HAZE FROM/TO parameters to display the haze with more shades. *Haze Mode* displays the same Summary Data Parameters as *Particle Mode.*

This mode is for replotting only, not for scanning. Wafer scans should be done in Composite Mode only.

USING DATA COMPARISON DISPLAY

Often it is useful to compare data before and after a processing step. The Surfscan 4500's non-volatile memory can store 25 summaries for side-by-side comparison with 25 current summaries held in a buffer.

The Data Comparison Display is available in both *Composite Mode* and *Particle Mode.* Do not alternate between these modes, however, or you will be comparing "apples" to "oranges". Check that the two sets of parameter values are the same when comparing wafers – particularly if the histogram cursors have been used.

❶ Scan a wafer or cassette of wafers.

❷ When ready to store the Summary Data for the wafer or wafers (you can scan up to 25 wafers before storing them), press [NXT] while the Data Display is on the monitor. The Data Comparison Display will appear. The column marked "CURRENT ID" with the ID#'s of the wafers just scanned is still in temporary memory (it will be lost when the Surfscan 4500 is powered down).

❸ To store the data, press [ENT]. The ID#'s for the stored data are transferred to the column marked "STORED ID." If there were 25 wafers in the "CURRENT ID" column, they will be in the same order in the "STORED ID" column. If there were less than 25 and there were already some wafers in the "STORED ID" column, the new stored wafers will "push" the other ones down the stack.

❹ To leave the data comparison display, press [ABT].

❺ Scan another wafer or cassette of wafers. This set of Summary Data is now put into the "CURRENT ID" column.

❻ To compare data, press [NXT] while the Data Display is on the monitor. Now you can select the specific wafers to compare by moving two cursors on the two columns of ID#s. Select the highlighted cursor with [SEL] and then move it up and down with [↑] and [↓] or from one column to the other with [←] or [→]. The boxed cursor remains where it is until selected with [SEL]. The two columns of Summary Data are displayed for the chosen wafers. If an 80-column printer is used, this screen can be printed: press [PRINT].

❼ Press [ABT] to leave the Data Comparison display and return to the Data Display.

Erasing Buffers

Summary data of wafers stored in non-volatile memory can be erased by pressing [PLT], [ABT].

Wafers stored in volatile memory can be erased by removing the sender cassette for at least four seconds.

MULTIPLE SCANS OF A SINGLE WAFER FOR IMPROVED COUNT

❶ Erase the comparison buffer by pulling cassette from sender for 4 seconds minimum.

❷ Scan a wafer and press [MENU] during the scan.

❸ Wait for the scan to complete and the MENU to show on the screen. Then press [START] again.

❹ Repeat the process up to 25 times.

❺ After the last scan, press [NXT]. MEAN, STD, MIN and MAX of the Particle Counts will appear on the screen.

2.8 INTERPRETING FUNCTIONS LINE

The operating function of the Surfscan 4500 is displayed on the Functions Line at the bottom of the Data Display.

PROCESSING—The processor is busy.

PRINTING—The Surfscan 4500 is currently transmitting data to the printer.

AREA—The Surfscan 4500 is currently plotting AREA.

STOP—The Surfscan 4500 has been stopped with [STOP], and will wait until restarted.

HEPA—The HEPA filter fan is on.

MENU—[MENU] has been pressed, the MENU will be displayed when the current phase is done (such as fetching, scanning, or unloading).

PART—Using *Composite Mode*, the Particle Map (yellow) is displayed or will be when the current phase is done.

HIST—Using *Composite Mode*, the Histogram (orange) is displayed or will be when the current phase is done.

HAZE—Using *Composite Mode*, the Haze Map (blue) is displayed or will be when the current phase is done.

YELLOW—Using *Particle Mode*, the yellow overlay is displayed or will be when the current phase is done.

ORANGE—Using *Particle Mode*, the orange overlay is displayed or will be when the current phase is done.

BLUE—Using *Particle Mode*, the blue overlay is displayed or will be when the current phase is done.

ZOOM—The Surfscan 4500 Display is currently in the ZOOM mode.

AUTO—The operating mode is *Automatic Mode*. If this cell is blank, the operating mode is *Manual Mode*.

1WFR—The transfer mode is *One-Wafer mode*.

2.9 CASSETTE FUNCTIONS

LOADING CASSETTES

Cassettes are regularly removed and replaced during operation. When the sender cassette is empty, the Surfscan 4500 message window prompts with

```
Initialize New Cassette
```

The prompt also appears:

- When a full receiver cassette must be replaced with an empty cassette before the wafer on the puck can be unloaded.
- When there is no receiver cassette in place for the puck to unload a wafer (TRANSFER MODE = MULTI).

To initialize a sender cassette:

❶ Make sure wafers are properly seated in the cassette.

❷ Place cassette with wafers on the tilted indexer platform. Slots of cassette should be toward the center of transporter so wafers can be accessed by the handler. Check that the cassette sits properly on the locator block and its locating bar is resting in the block's groove.

❸ Press [CASS] to initialize. The direct access indexer will scan for the presence of wafers in the cassette.

When encountering a partially filled receiver cassette, the puck will unload the scanned wafers below the bottom occupied slot. **It will not fill empty slots between other wafers.**

Do not remove the cassette from the indexer platform while a wafer is on the puck and is being unloaded. Always wait until the puck has unloaded the wafer before removing the cassette.

UNLOADING CASSETTES

A cassette can be unloaded in *Manual Mode* whenever the puck has stopped at home (to turn *Automatic Mode* off, press [AUTO]). Wait until the puck has finished fetching or unloading and has returned to the home position. When the puck has stopped at home, lift the cassette straight up. The indexer platform rises and tilts back, ready for another cassette to be loaded.

To raise the indexer platform and cassette, before unloading the cassette, press [HOME] after the puck has returned home without a wafer.

RANDOM–ACCESS SENDER/INDEXER

Without initialization, the Random-Access Sender/Indexer will fetch wafers from the bottom occupied slot of the cassette. Measuring wafers without initializing is discussed as "Reverse Sequential Scanning".

To access other slots, the indexer must be initialized to "map" available wafers.

Press [CASS] to initialize a cassette. The Random-Access Sender/Indexer lowers the cassette and optically detects occupied slots. Wafers are mapped on the monitor within 25 vertically-stacked boxes. Full slots are indicated by a number inside the box – if there is no number, there is no wafer in that slot. Slot 1 is the cassette's bottom slot.

Wafers can be randomly selected from an initialized cassette. Use [↑] or [↓] to select wafers from the map. The selected slot number will be highlighted.

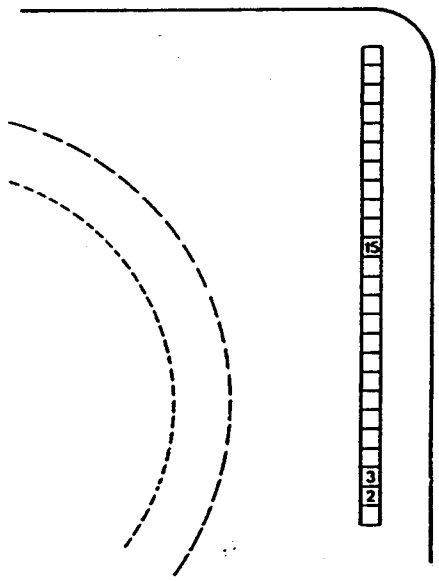

Figure 10: Cassette Map
(showing slots 2, 3, and 15 occupied)

2.10 SCAN FUNCTIONS

The scanning sequence of the wafers in a cassette may be either *normal sequential, reverse sequential,* or *random.*

- **normal sequential scanning:** all wafers scanned from top to bottom.
- **reverse sequential scanning:** all wafers scanned from bottom to top.
- **random-access scanning:** selected wafers scanned in *Manual Mode*
- **programmed sequential scanning:** selected set of wafers scanned in *Automatic Mode*

NORMAL SEQUENTIAL SCANNING

Scanning begins with the wafer in the top occupied slot. This scan method is called "normal" because wafers are transferred from sender to receiver cassettes in their same respective order.

The process of unloading the wafer depends on the value of the TRANSFER MODE parameter (see *Transfer Mode*):

❶ Load a cassette on the indexer platform.

❷ Press [CASS] and wait until the indexer has initialized the cassette and the cassette map appears on the Data Display.

❸ When ready to scan, press [START].

REVERSE SEQUENTIAL SCANNING

Wafers are scanned sequentially from the bottom slot up and transferred to receiver cassettes in reverse order. A cassette Map **does not** appear.

This method of scanning requires that TRANSFER MODE = MULTI.

❶ Load a cassette on the indexer platform. **Do not** press [CASS].

❷ When ready to scan, press [START].

RANDOM–ACCESS SCANNING

Individual wafers can be randomly selected from a cassette for scanning.

1. Load a cassette on the indexer platform.
2. Press [CASS] and wait until the indexer has initialized the cassette and the cassette Map is displayed.
3. Select a wafer on the cassette map with [↑] or [↓].
4. Press [START].

If the Surfscan 4500 is in *Manual Mode* and another wafer is not selected from the cassette Map, it defaults to "Normal Sequential Scanning" when [START] is pressed and scans the next lower wafer. Otherwise, a wafer may be chosen out of sequence using the cursor keys.

In *Automatic Mode*, the Surfscan 4500 automatically fetches the next lower wafer and continues the cycle until all wafers have been scanned and unloaded in the proper cassette.

PROGRAMMED SEQUENTIAL SCANNING

While in *Automatic Mode*, the Surfscan 4500 can be programmed to scan selected wafers from an initialized cassette.

1. Use the cursor keys on the cassette map to select the wafer you want to have programmed.
2. Press [ENT]. The number in the highlighted compartment disappears, indicating that this slot has been programmed.
3. Select another wafer and press [ENT] to program it. Continue until the desired set is programmed. If you make a mistake and program the wrong wafer, press [AUTO] to toggle into *Manual Mode* to erase the programming.

The program is lost whenever a scan is stopped or a cassette is removed.

TRANSFER MODE

When TRANSFER MODE = SINGLE, the wafer is returned to the slot from which it was fetched.

When TRANSFER MODE = MULTI, the wafer is unloaded in the proper receiver according to the measurement results and sort parameter values. The proper receiver is different for the two Surfscan 4500 configurations.

When TRANSFER MODE = 1WFR, substrates may be manually loaded and scanned. No cassette may be used.

(The status window displays "1WFR".) Single wafers, broken wafers or other substrates may be scanned in this mode.

Each wafer must be manually placed on the vacuum puck.

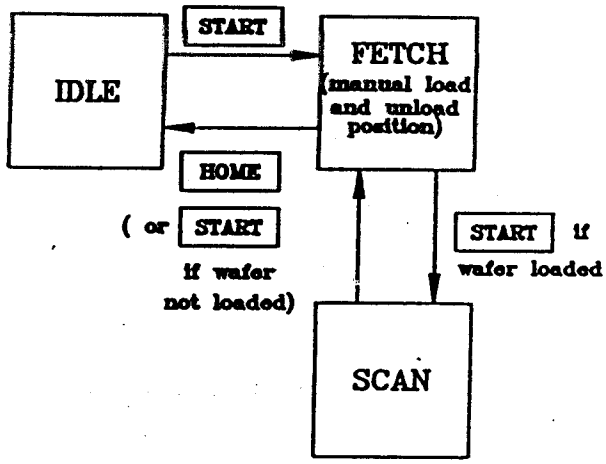

Figure 11: One-Wafer Mode Cycle

❶ Remove all cassettes from the indexers.

❷ Press [START]. The puck moves to the One-Wafer load/unload position and waits. The Functions Line shows "1 WFR."

❸ To abort this measurement mode at this point, press [START] to send the puck home.

When loading substrates, be sure edges do not extend beyond the edge of the indexer platform. This is especially critical for larger substrates (approaching 150 mm in width).

❹ Using a vacuum wand, manually place the substrate on the puck (the wafer must extend beyond the indexer platform).

❺ Press [CASS] to turn the vacuum on, securing the wafer on the puck.

6. Press [START]. The substrate is carried inside the scan housing, data is displayed, and the substrate is returned to the load/unload position.

7. To rescan the substrate press [START].

8. Press [CASS] to release the vacuum and remove the substrate.

Two—Indexer Configuration

In the two-indexer configuration, accepted wafers are unloaded in the empty slot below the lowest wafer in the receiver cassette. Rejected wafers are unloaded in the slot from which it was fetched.

Three—Indexer Configuration

With two designated receivers, the Surfscan 4500 unloads accepted wafers in the front receiver. Rejected wafers are unloaded in the rear receiver. Wafers are always unloaded in the empty slots below the lowest wafer already in the cassette.

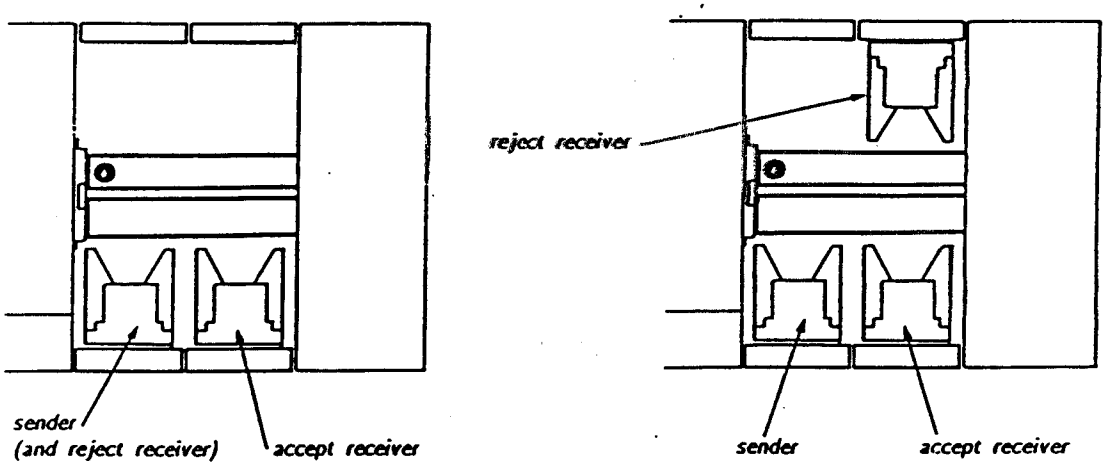

Figure 12: Indexer Configurations

2.11 SCAN MODES

There are two scan modes: Manual Mode and Automatic Mode.

- Manual Mode allows each scan of a wafer carried in a wafer cassette to be analyzed in detail.
- Automatic Mode measures all wafers in a wafer cassette, subjecting them all to the same parameter values.

MEASURING IN MANUAL MODE

Manual Mode allows a single wafer to be fetched from the sender cassette and scanned when START is pressed.

This mode permits extensive analysis of each wafer.

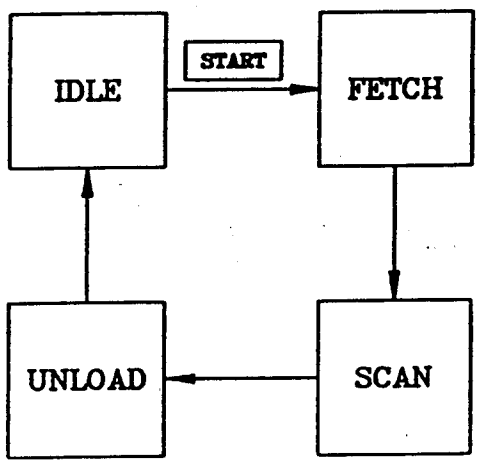

Figure 13: Manual Mode Cycle

After the scan is complete, the Data Display appears on the monitor. The process of unloading the wafer depends on the value of the TRANSFER MODE parameter (see *Transfer Mode*).

❶ Press [MENU] to display the MENU.

❷ Load the cassette on the sender indexer. Initialize, if desired, by pressing [CASS].

❸ (If TRANSFER MODE = SINGLE, skip to step ❹) Place an empty cassette on the receiver indexer(s).

❹ If the Functions Line displays "AUTO," press [AUTO] to toggle it off.

❺ If the sender is initialized and you want to select a specific wafer for scanning, use [↑] or [↓] to select the wafer on the cassette Map.

❻ If desired, enter the ID number to identify the cassette on printouts.

❼ Press [START]. The puck fetches a wafer and carries it into the scan housing for measurement.

MEASURING IN AUTOMATIC MODE

Automatic Mode repeats scanning cycles until all wafers from the sender cassette are scanned. [START] initiates the automatic cycle.

Automatic Mode can be stopped or started anytime during fetching, scanning, or unloading - just press [AUTO]. As the scan cycle finishes, the Surfscan 4500 "checks" to see if the mode has been changed.

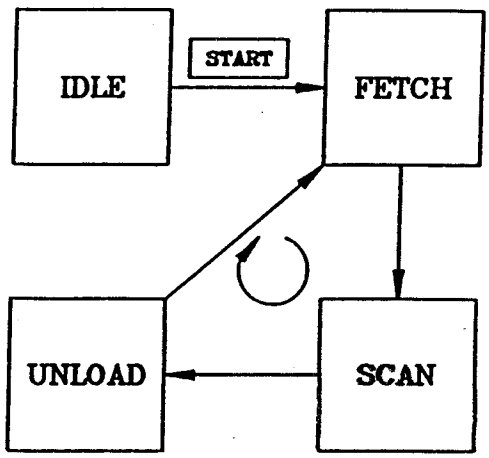

Figure 14: Automatic Mode Cycle

After the scan is complete, the Summary Data (and Particle Map, if toggled on) appears on the monitor. If AUTOPRINT = ON, the printer begins printing. Neither the Histogram nor the Haze Map are displayed in this mode. (For 150 mm wafers, only the first wafer's Particle Map is shown – for all other wafers in the cassette, only the Summary Data is displayed.)

Sorting

For sorting wafers cassette-to-cassette, use *Automatic Mode* with TRANSFER MODE = MULTI. For printouts, set AUTOPRINT = ON and select the desired form of the printout (use SHORT for fast throughput). See *Transfer Mode* for sorting information.

Interrupting Automatic Mode

Interrupting to Analyze Scan Data

Scan data will often prompt you to analyze a particular wafer further. The automatic cycle can be interrupted so Histogram cursors or Data Display parameters can be changed.

Press [AUTO] to change to *Manual Mode* before the current wafer is unloaded. The measurement results can now be analyzed.

Press [AUTO] to change back to *Automatic Mode* and [START] to resume scanning.

Interrupting to Change MENU

The MENU can be displayed anytime by pressing [MENU].

If this is done before the wafer reaches the scan port, the puck will pause. The MENU will be reappear to allow parameters to be changed. Change the values and press [START] to continue.

If [MENU] is pressed while the wafer is actually being scanned, the scan will be completed and the wafer brought back to the *scan entry point* (the closest point to being scanned). Now you can change the parameters and press [START] to rescan the wafer.

Interrupting to Change Cassette

If the Surfscan 4500 prompts for another cassette, it will pause and change to *Manual Mode*. Load the cassette, initialize (if desired), press [AUTO], then press [START] to continue.

If you wish to remove a cassette before *Automatic Mode* finishes scanning all wafers in a sender or filling a receiver, there are two options: (1) reject the current scan by returning it to the sender so it can be rescanned, or (2) continue the scan and unload the wafer in the correct receiver before stopping.

Reject Current Scan

1. Before the wafer reaches the scan port, press [HOME]. This sends the puck and wafer to the home position.
2. Press [MENU] to display the MENU. Set TRANSFER MODE = SINGLE.
3. Press [START]. The wafer should be unloaded to the slot from which it was removed.
4. Remove the cassette(s). Be sure to set TRANSFER MODE = MULTI if the next batch of wafers is to be sorted.

Continue Current Scan

1. After the wafer has been fetched (but before it is unloaded) press [AUTO] to change to *Manual Mode*. The Functions Line should indicate the change.
2. After the puck unloads the wafer and returns home, remove the cassette(s).

2.12 STOPPING AND RESTARTING

EMERGENCY STOP

Press [STOP] to prevent personal danger or damage to the Surfscan 4500. Pressing [STOP] automatically places the instrument into *Manual Mode*. If the wafer scan has already begun, rescan the wafer because a mid-scan halt affects data.

SCAN ABORT

To stop during normal operation, press [HOME]. Measurement will abort.

SCAN REPEAT

If [MENU] is pressed during the scan, the instrument will finish the scan, but retain the wafer for another scan. The screen displays the scan MENU which may be changed before rescanning.

RESTARTING

To resume normal operation after any stop, press [START].

If [MENU] was used to stop, the scan continues or the wafer is rescanned.

If [HOME] was used to stop, the wafer on the puck is unloaded.

RESETTING SYSTEM

If the Surfscan 4500 keyboard "locks up" (fails to respond to repeated entry), press the system reset button on the left side (above the printer connector).

Whenever the system reset button is pushed while a wafer is on the puck, the Surfscan 4500 assumes the wafer should be unloaded into a cassette in *Manual Mode*.

2.13 PRINTING

Either a 20- or an 80-column printer can be selected from the PRINTER TYPE parameter of the MENU. The 20-column format allows only the Summary Data or Short Summary to be sent to the printer. If a graphics printer has been interfaced to the parallel port, set the PRINTER TYPE parameter to 80-COL.

Printer data is transmitted from the parallel port connector labeled "OUT 1 PRINT" on the I/O Panel. System configuration parameters allow a choice of two types of printers and six types of output (although the 20-column printer can only print alphanumeric data).

OUTPUT

There are six values for the PRINTER OUTPUT parameter. The tables below show the output and the applicable PRINTER TYPE values for the three display modes: *Composite, Particle* and *Haze.*

COMPOSITE MODE

VALUE	OUTPUT	PRINTER TYPE 20 COL	80COL
SUMMARY	Summary Data	X	X
SHORT	Short Summary Data	X	X
YELLOW	Particle Map		X
ORANGE	Histogram		X
BLUE	Haze Map		X
HISTBL	Histogram Table		X

X = permitted output

PARTICLE MODE

VALUE	OUTPUT	PRINTER TYPE 20 COL	80COL
SUMMARY	Summary Data	X	X
SHORT	Short Summary Data	X	X
YELLOW	Map of small particles		X
ORANGE	Map of medium particles		X
BLUE	Map of large particles		X
HISTBL	Histogram Table		X

X = permitted output

HAZE MODE

VALUE	OUTPUT	PRINTER TYPE 20 COL	80COL
SUMMARY	Summary Data	X	X
SHORT	Short Summary Data	X	X
YELLOW, ORANGE, BLUE	HAZE Map		X
HISTBL	Histogram Table		X

X = permitted output

After installation of the Surfscan 4500, check the [-] [MENU] parameters to ascertain that the appropriate printer options are chosen. At present options are limited to three printers — Epson, Citizen and Okidata.

PRIORITY PRINTING

When the data you wish to print is on the Data Display, press [PRINT].

If the 80-column printer is selected and one of the "color" printouts chosen, the corresponding word in the Functions Line will be highlighted. For example, if you are using *Composite Mode* with all three overlays on the Data Display and YELLOW is the PRINTER OUTPUT parameter value, then the word "PART" on the Functions Line will be highlighted while the Particle Map is displayed. Pressing [PRINT] causes the Particle Map to be printed. If the Particle Map is turned off (by pressing [YELLOW]), the next (ORANGE) printout is selected *automatically* and is revealed by highlighting of "HIST". Now the Histogram could be printed by pressing [PRINT]. The priority for switching the printouts by turning the overlays ON and OFF is left to right (i.e. PART, HIST, HAZE – yellow, orange, blue).

If the 20-column printer is selected but is not printing, check the value for the PRINTER TYPE and PRINTER OUTPUT parameters.

The standard 20-column printer uses thermal paper available from Tencor Instruments. Replace it with the same type or equivalent to ensure proper print intensity. Use cleanroom paper if the printer is being operated in the cleanroom area – normal paper releases many particles that affect cleanroom processes.

Because the 20–column printer does not detect whether the paper has run out, check it periodically. DO NOT operate the printer if the paper is not advancing or if it is out of paper.

2.14 KEYBOARD FUNCTIONS

ABT

MENU: Aborts the present action. If pressed before entering direct-entry parameters, replaces the previous value of the parameter.

DATA DISPLAY: If Histogram is displayed, returns Histogram cursors to boundaries specified by Data Display parameters.

MENU: If changing the ID#, it restores the previous value.

Use of **ABT** in the data display generally returns to the previous display. Pressing **ABT** several times will "back up" the display a "page" at a time.

PRINTING: Aborts data transmission to printer.

HELP SCREENS: Returns operation to the phase when **HELP** was pressed.

AUTO

Toggles between *Manual* and *Automatic* measurement modes. If "AUTO" is displayed in the functions line, the Surfscan 4500 is in *Automatic Mode*. If blank, it is in *Manual Mode*.

CASS

Manual Mode and Automatic Mode: Pressing **CASS**, while a cassette is on the indexer platform initializes the cassette. (Refer to *Initializing Cassettes*).

One-Wafer mode: In *One-Wafer Mode*, **CASS** controls the vacuum valve to the puck. Pressing and holding **CASS** cuts off the vacuum so a wafer can be loaded or unloaded manually. When **CASS** is released, vacuum is turned on to hold the wafer in place. (Vacuum automatically shuts off if the puck does not have a wafer, preventing vacuum drain.)

ENT

MENU: Enters changes to direct-entry parameter.

DATA DISPLAY: After **#** is pressed and new ID# typed, stores ID#. Programs slot selected from Cassette Map of initialized indexer while in *Automatic Mode*. Stores in *Compare Mode*.

HELP

Online HELP function.

[HEPA] Toggles the fan for the HEPA filter. The Functions Line displays "HEPA" while the fan is turned on.

[HOME] Instructs the Surfscan 4500 to move the puck to home position. If the puck holds a wafer, it can be unloaded by pressing [START]. If the puck is at home and has no wafer on it, pressing [HOME] raises the indexer platforms and resident cassette.

[MENU] Toggles between MENU and DATA DISPLAY. The Functions Line indicates whether [MENU] has been pressed while the instrument was doing another task.

[-][MENU] Calls PERIPHERALS MENU. The left portion of the MENU is for printer options. If the SECS option has been installed, the right portion of this MENU displays SECS options.

[NXT] **MENU:** Moves the cursor between MENU quadrants. The cursor returns to the last changed parameter when returning to the quadrant.

DATA DISPLAY: Shows the Data Comparison display.

[PLT] **DATA DISPLAY:** Plots (or replots) Data Display. Can be used after changing Data Display parameters or after moving Histogram cursors or after moving Area Zoom Square on Particle Map. While entering ID#, [PLOT] types a blank space. When in the MENU, users can change the Data Display and replot data without rescanning.

[PRINT] **MENU:** Transmits data to the printer via the I/O port. Before printing, check two system configuration parameters: PRINTER OUTPUT and PRINTER TYPE. There is a 3-second time-out feature. If no printer is acknowledged at the indicated port, it will automatically try to initialize through the alternate port.

[SEL] **DATA DISPLAY:** selects the movable Histogram cursor if Histogram displayed. .

HELP: Displays the first Help Screen of the topic chosen on the HELP SCREEN.

ZOOM: If the Particle Map is displayed but the Histogram is not, [SEL] begins Area Zoom analysis by displaying Area Zoom Square on Particle Map

ID#: Selects alpha character.

[START] Starts or restarts the next phase of measurement or handling operation.

[STOP] Immediately stops the present task.

Scan data may be affected by [STOP] if the wafer has already been partially scanned. Use this for emergencies only (use [HOME] or [MENU] for normal stops).

From this paused state, normal operation resumes with [START]. Pressing [HOME] sends the puck home for idle state. After the Surfscan 4500 is stopped with [STOP], the Functions Line displays "STOP."

[YELLOW] Toggles the display of the yellow overlay.

Compos Mode: toggles display of Particle Map.

Particle Mode: toggles display of smallest particles.

Zoom Mode: toggles display of Particle Map.

[ORANGE] **Compos Mode:** toggles the display of the Histogram.

Particle Mode: toggles display of medium particles.

Zoom Mode: toggles display of the partial histogram.

[BLUE] **Compos Mode or Haze Mode:** toggles the display of the blue overlay (Haze Map).

Particle Mode: toggles display of largest particles.

Zoom Mode: toggles display of 16x Particle Map.

[↑]/[↓] **MENU:** Moves the parameter cursor up or down within a quadrant.

DATA DISPLAY: If sender initialized, select wafer slot on cassette Map. Moves cursor up or down the parameters in the MENU quadrant.

HELP SCREEN: Move the cursor up or down the topics in the HELP SCREEN.

ID#: Move the cursor up or down Alpha Display to choose alpha characters.

[←]/[→] **MENU:** For listed entries (with < >), these cycle through options. If parameter value is direct entry (no < > adjacent parameter), then [←] can be used as a "delete backward" key. [→] works as [ABT] function.

DATA DISPLAY: Move the Histogram cursor selected with [SEL]. Data for Histogram region between the cursors is displayed as a Summary Histogram in Summary Data.

HELP SCREEN: Select topic.

[#] **MENU:** Allows the MENU Number (1-25) to be changed.

DATA DISPLAY: Allows the ID# to be changed.

2.15 MEASURING HIGH–SCATTER WAFERS

High-scatter wafers generally have a hazy or milky appearance when reflected objects are viewed in them. Such wafers present a special challenge to wafer inspection instruments because of the way signal processing is done. First, the total scattered-light signal passes through a wideband, DC-coupled amplifier (the Haze channel) and a high-frequency AC coupled channel (Particle channel).

Two characteristics of high-scatter wafers which can affect measurements are the average amount of scatter, which is measured by the Haze channel, and granularity, or the amount of local variation of this scatter from point to point. If the system sensitivity (PMT gain) is set too high, the wideband DC amplifier can overload, clipping off particle signals and producing a deceptively clean wafer map. If the wideband amplifier is not overloaded, the granularity signal can still produce a high apparent count in the particle channel.

You can use the haze measurement as a guide to avoid overloading the system with high-scatter wafers. Proceed as follows:

1. Place the PPC in the SINGLE mode and the display to COMPOSITE.
2. Set the MAX SIZE to 1024.
3. Set the THRESHOLD LEVEL to 512, HAZE FROM to 51,200 and HAZE TO to 102,400.
4. Run the wafer and observe the particle (yellow) and haze (blue) displays, and note the HAZE AVERAGE TOTAL.

Divide the HAZE AVERAGE TOTAL by 100. If the quotient is less than 1023, you can continue with the measurement. If the quotient is 1023 or higher, measurement is NOT recommended.

If the quotient is between 512 and 1023 (or if the haze map is mostly filled with blue areas), leave the MAX SIZE at 1024. If the quotient is less than 512 (haze map mostly clear), you can lower the MAX SIZE one step at a time and scan the wafer again after each step. Leave the THRESHOLD and HAZE FROM and HAZE TO settings alone. Stop when either the haze map becomes mostly blue or the particle map becomes filled with yellow dots.

Now the procedure depends on which map was filled. If it was the haze map, and the particle map has few yellow dots, then leave the MAX SIZE setting where it is and lower the THRESHOLD setting, taking measurements until the particle map starts showing an interesting feature. If only random dots show up which suddenly increase with small reductions in THRESHOLD, then you have reached the "granularity limit" of the wafer.

If the particle map was crowded with the THRESHOLD at half of MAX SIZE, the wafer is a high-granularity type. In this case, you should increase the MAX SIZE setting by two steps to give the instrument more dynamic range and then lower the THRESHOLD setting, making measurements until the granularity limit is reached. This will yield the most accurate measurement for this type of wafer.

Note: A faster way of finding the granularity limit is to observe the particle histogram when the particle map is crowded (you may have to measure at a lower THRESHOLD setting to do this). Generally, the histogram will rise steeply toward the low end and will appear to cut off at some higher value; this can be regarded as the granularity limit, and further measurements should be made with THRESHOLD or PARTICLES FROM set at this value or higher.

AVERAGE HAZE READINGS

High-scatter wafers can produce HAZE AVERAGE TOTAL readings that are not the same at all MAX SIZE settings. This happens because the highest haze reading that the Surfscan 4500 can produce is MAX SIZE divided by 100, regardless of that setting. In effect, the haze channel becomes saturated if the instrument is made too sensitive. To avoid this, proceed as follows:

1. Set MAX SIZE to 1024. Set HAZE FROM at 1023 and HAZE TO at 1024, enable the haze display and measure the wafer.

2. Observe the haze map (it is now set up to display only saturated or "overloaded" haze pixels.) If it is blank or shows only a few blue dots, the HAZE AVERAGE TOTAL will be valid. If, however, the haze map is blue over a substantial area, the actual average haze is probably higher than 102400 PPM, although the HAZE AVERAGE TOTAL reading will be this value or slightly less.

If the HAZE AVERAGE TOTAL is less than 1000, you can remeasure at lower MAX SIZE settings to get a more accurate reading of average haze (at MAX SIZE of 1024, the average haze is rounded off to a multiple of 100 PPM). Leave the HAZE FROM and HAZE TO settings alone when going to more sensitive ranges, and stop when blue areas appear in the haze map. (if necessary, go back up in MAX SIZE until the haze map shows a few or no blue dots).

DOUBLE HIT MODE

Measurements using the double-hit mode of the PPC can be done on high-scatter wafers to help differentiate particles from background noise. This must be done WITH CARE. First, the proper Threshold setting and Max size setting should be found as above in the single hit mode. The threshold setting would not be more than 20% of full scale and the particle map should not have more than 50 points per cm^2. Then engage the double-hit mode and measure at lower thresholds until the desired display is obtained.

If any new wafer is measured, even a similar type, always go back to the single-hit mode before remeasuring so that the PPC will not be overloaded. Remember that an overloaded PPC can lead to a nearly blank display, so if the wafer looks deceptively clean, watch out!

In the Surfscan 4500, the maximum haze that can be measured at any point on the wafer is (in parts per million) 100 times the MAX SIZE in μm^2 and gives a full scale reading at that point. This means that if the Haze is mostly above the full scale range at a given MAX SIZE, the HAZE AVG TOTAL will also saturate at the full-scale reading. This has two effects:

First, the highest HAZE AVG TOTAL reading possible will be 102,400 PPM (10.24%) on the Surfscan 4500, even if actual Haze is higher. Secondly, if the HAZE AVG TOTAL is less than these figures but still high, the HAZE AVG TOTAL values will be consistent (and accurate) as long as the MAX SIZE setting is high enough to avoid saturation of any of the low haze pixels. But if MAX SIZE is placed too low, the HAZE AVG TOTAL figures will get lower and will track the full-scale values at that setting. To observe Haze saturation effects, set the HAZE FROM value to the full scale value and replot the Haze Map. Only saturated Haze pixels will show up. The Haze may also be non-uniform and saturate only a portion of the Haze Map. In this case, the HAZE AVG. TOTAL reading will be somewhat lower than the true value.

SECTION 3 -- THEORY OF OPERATION

An understanding of light-scattering, collection, and optical signal processing is useful when determining data collection parameters. For instance, when measuring high-haze wafers, it is important to understand how the PPC threshold can be manipulated to eliminate noise and isolate particles. This section describes important aspects of the scanning system.

In general, particles which are large compared with the wavelength of incident light (the wavelength used in the Surfscan 4500 is $\lambda = 0.6328\ \mu m$) scatter light preferentially (bright components are scattered in a few directions). This is exemplified by the epi spike shown in the figure below.

In contrast, isolated particles which are small compared with the wavelength of incident light tend to scatter light isotropically (light is uniformly scattered over many angles).

The collection system of the Surfscan 4500 covers an effective solid angle approaching π out of a possible of 2π sterradians, thereby maximizing collection of all scattered components.

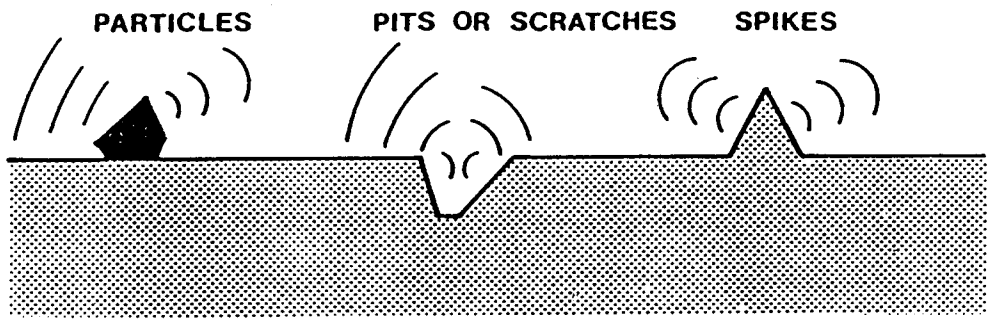

Figure 15: Scattering is Dependent on Particle Characteristics Such as Shape

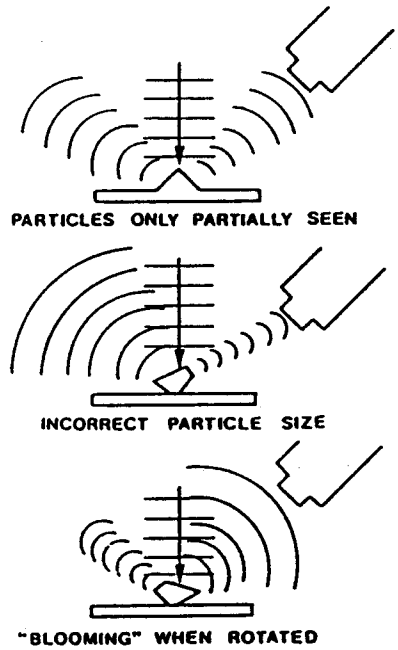

Figure 16: Limitations of a Small Collection Angle

Scattering Cross—Section

The Surfscan 4500 analyzes light scattered from particles illuminated with a calibrated laser spot. Since the intensity of light scattered from a particle depends on the size of the particle, its shape, the reflectivity of the substrate, and the optical properties of the particle (particularly the dielectric constant) scattered light intensity cannot be directly related to particle size. For this reason, the Surfscan 4500 displays scattering cross-section (NOT particle size) on its horizontal axis. The scattering cross section is the ratio of the power scattered by the particle (watts) to the power density (watts/cm^2) incident on it.

As the particle size decreases below the wavelength of light the scattering decreases very rapidly. For diameters much smaller than a wavelength (e.g. values below 0.2 μm) the scattering cross-section decreases as the sixth power of the diameter. Thus, a 0.1 μm diameter sphere scatters only 1/64 as much light as a 0.2 μm diameter sphere.

For dielectric spheres in free space, the scattering cross-sections can be calculated from Maxwell's equations and represent Mie Theory. For particles on substrates, no such theory is available and even numerical simulations are extremely tedious. The instrument is therefore calibrated through experimental measurement of various latex sphere sizes on different substrates.

Scattering phenomena are very complex and cannot be described in a few sentences. However, it should be noted that the scattering cross-sections for a particle on a substrate is generally lower than for the same particle in free space. It also should be noted that high-reflectivity substrates allow more accurate sizing/location of small particles.

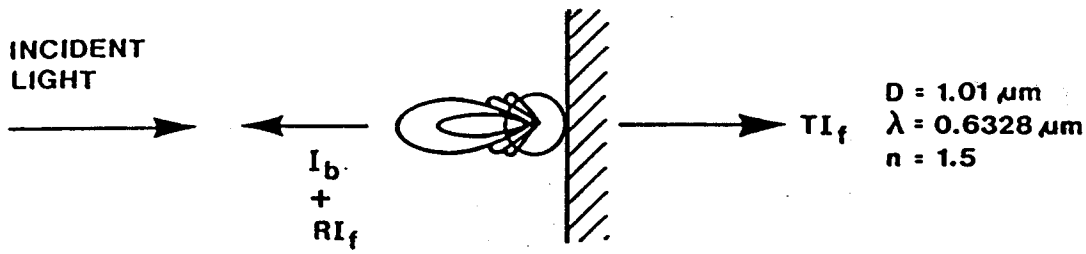

Figure 17: Light Scattered From a Particle Supported by a Substrate

3.1 SCANNING SYSTEM

Basic principles of the Surfscan 4500 can be explained in general terms through a description of major components.

Beam Generation and Spot Focusing

Light from a linearly polarized laser passes through a double right-angle prism which folds the light path and converts the beam to circularly polarized light (the circular polarity eliminates events dependent on polarity). Lens L1 focuses the light in the spatial filter which removes stray laser light. The diverging light leaving the spatial filter is turned 90 degrees by the plane mirror M and enters the focusing lens L2. The scanning mirror oscillates, sweeping the beam which is focused by the lens L2 onto the substrate.

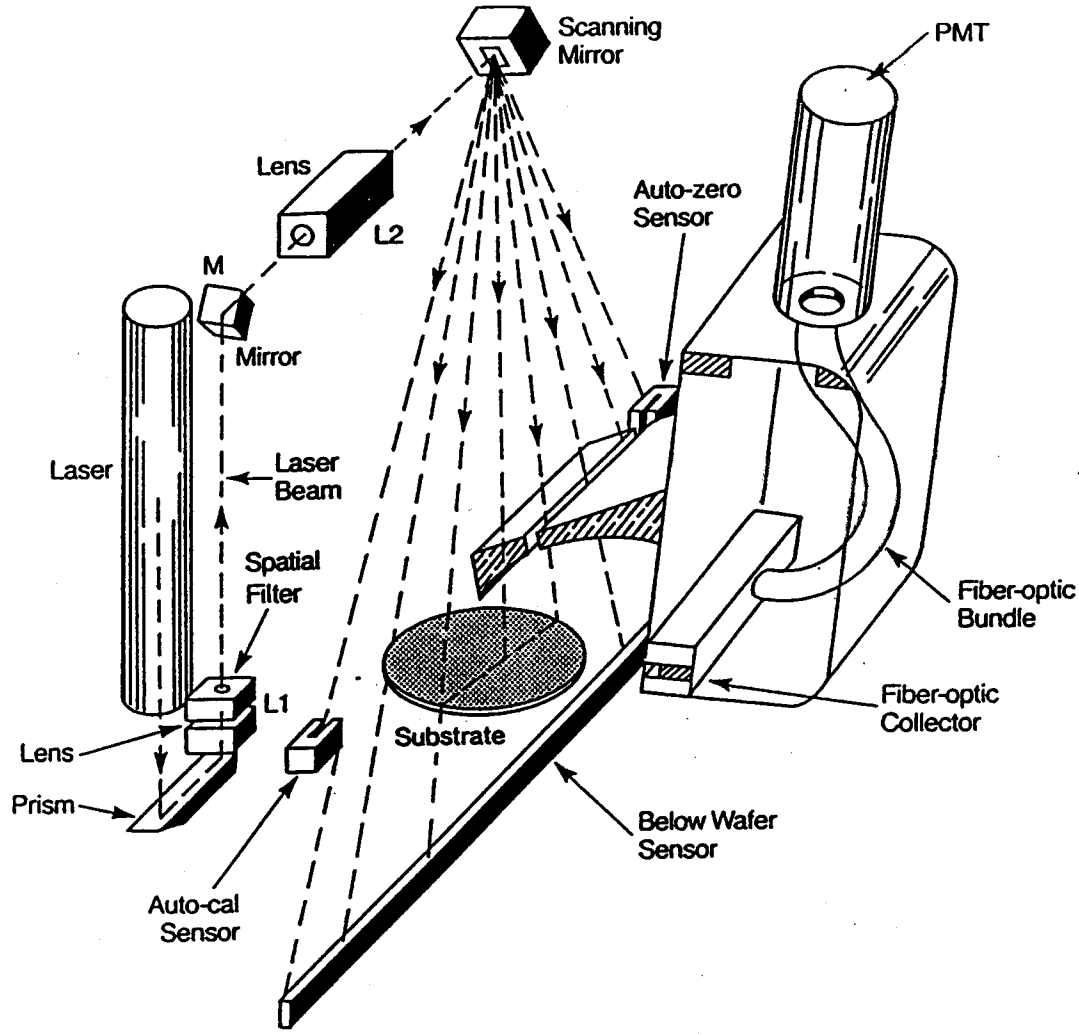

Figure 18: Surfscan Light-Sensor and Detection Systems

Laser Scan Path

The beam sweeps the substrate while the substrate is moved perpendicularly to the scan line. The result is a spot 100 μm in diameter tracing scan lines which are 25 μm apart.

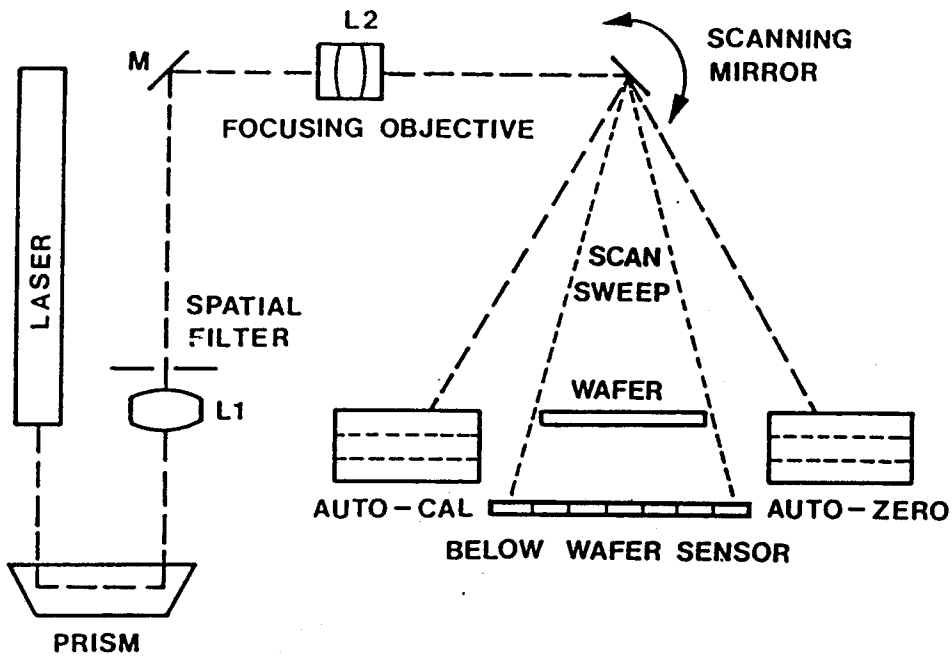

Figure 19: The Laser Scan Path

The focus of the beam is tightly controlled over the entire area of the substrate to insure that the beam intensity is nearly the same for all particles. Scan overlap prevents the "worst-case" position from receiving less than 89 percent of the maximum beam intensity. Thus, very high sensitivity and uniformity across the wafer can be achieved. On average, the illuminated particles receive 96% of the maximum intensity.

Elliptical Mirror

The elliptical mirror collects scattered light while significantly reducing background noise. Light scattered by particles in the first focal point F_1 will always be focused at the second focal point F_2.

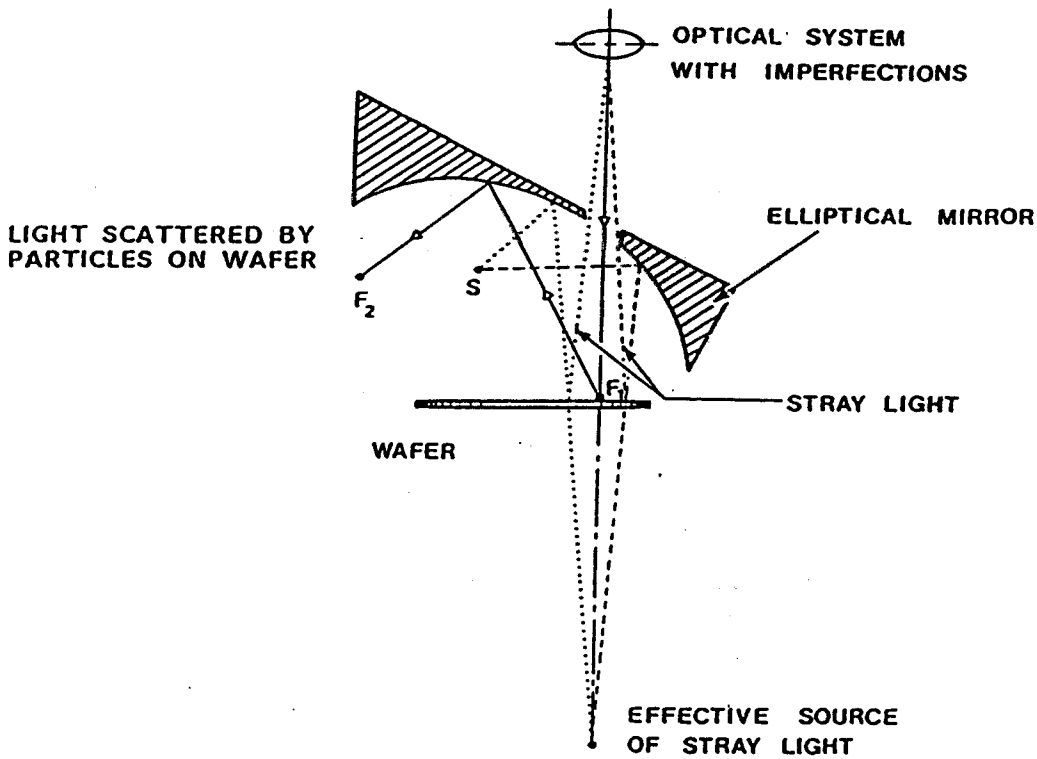

Figure 20: The Elliptical Mirror

Conversely, light from points other than F_1 will focus at non-collection points and will not enter the fiber optics collector.

Vertical plane mirrors at the ends of the elliptical mirror ensure that skew rays are returned to the focal line, improving the collection efficiency.

The aperture of the fiber optics collector, point F_2, measures the particle's scattered light and randomizes it to obtain a uniform response from the photomultiplier.

3.2 MEASUREMENT SYSTEM

The measurement system primarily consists of four components: The Photomultiplier Tube, Auto-Cal, Auto-Zero, and the Pulse Position Correlator (PPC). The Photomultiplier Tube (PMT), provides an electrical signal proportional to the integrated light. The Auto-Cal and Auto-Zero circuits enhance sensitivity.

The Auto-Cal circuit functions as a PMT "stabilizer" for ultra-high performance. To maintain long-term precision, it compensates for changes in the laser beam's intensity (resulting from aging or power supply fluctuation). In the Surfscan 4500, the scanning beam enters a small chamber after sweeping across the wafer. The Auto-Cal sensor is a miniature integrating sphere which samples laser intensity 400 times per second.

The PMT control-board compares the PMT signal during Auto-Cal with an internal standard during every laser scan. This makes the appropriate gain adjustments to the PMT while keeping the signal equal to the reference level.

An Auto-Zero sensor compensates for amplifier offsets, drift, and small amounts of stray and ambient light entering the detector. The sensor is positioned to scatter the minimum possible amount of light into the collector. The measured PMT signal at that point becomes the zero-reference point for PMT measurements from the substrate.

If the light level of the scattering exceeds system limits or the PMT has aged beyond specifications, the PMT circuitry is automatically disabled, and the user is notified on the monitor.

MEASURING WAFERS PLACED AT NON–STANDARD ANGLES

The Surfscan 4500 defines the edge exclusion of a wafer using a quadratic formula. If the major flat of a wafer is not parallel to the front of the cassette, the quadratic is, nevertheless, applied to the flat of the wafer (just as if it was an arc). Thus, a very large corner of the wafer may be excluded from measurement. To assure repeatability, it is important that all wafers measured at non-standard angles be placed at exactly the same angle each time (using a flat-finder).

SECTION 4 -- MAINTENANCE

This section describes service procedures which can be performed without special tools or training.

4.1 TROUBLESHOOTING

Symptom

Procedure

MENU not displayed when [MENU] pressed

Verify that the MENU Security Lock is not locked.

Keyboard not working

If a scanning or other operation is being done, wait a few moments; then try again.

Press the system reset button (on the left side I/O panel).

No power

Check all fuses: two for the Surfscan 4500; one for the monitor; and one for the printer.

Printer not printing

Verify that the printer cable is properly connected.

Reset by unplugging the printer power cord and reconnecting it. Try printing again.

Wafers rubbing or binding in cassette

Verify that the cassette is correctly loaded on the indexer platform.

Wafer dropped into transporter

If the wafer is unbroken, grasp it with a vacuum wand to retrieve.

If the wafer is broken, vacuum out the chips.

Wafer dropped inside scan unit

Call Tencor Instruments' Service Department for assistance.

ERROR MESSAGES AND PROMPTS

Operation-related messages are displayed in the Data Display's message window. If several messages must be displayed, the highest priority message appears until the condition is corrected; then any lower priority message(s) appear(s). Messages are not displayed simultaneously.

Calculating Edge Exclusion

The Surfscan 4500 is calculating the data table for a new EDGE EXCLUSION parameter. Edge Exclusion is calculated at power-up and whenever the EDGE EXCLUSION or SUBSTRATE parameters are changed.

Check Vacuum

Usually triggered by a sudden drop of vacuum – ascertain vacuum is at proper levels before continuing scan. Check that the wafer hasn't fallen from puck before continuing.

Graphics Card Reset

Call Tencor Instruments' Service Department if this message repeats often.

Max Size Not Displayed

Indicates that the value for the Data Display parameter PARTICLES TO or the right-hand Histogram cursor is less than the value for the Data Collection parameter MAX SIZE. Under these circumstances, data in these upper bins will not appear in the Summary Data. This message also appears on printouts indicating that not all of the data is displayed, or the largest particles have been ignored or not all of the particles are represented on the map.

Max Size or Threshold too Low

Indicates there is too much data for available memory or the data stream is faster than the system can handle. To correct this problem, set higher values for the Data Collection parameters MAX SIZE or THRESHOLD (both may require changing). The wafer is always rejected if this message appears during a scan. No meaningful data can be obtained with present setting.

Max Haze Over Max Haze

Displayed when at least one area on the wafer has a Haze value exceeding the value shown the Data Collection quadrant as MAX HAZE. As a result, the HAZE AVG. TOTAL value shown in the Summary Data may be incorrect because of an excessive amount of scattered light. MAX SIZE should be set to a higher value. The wafer is rejected if this message appears and there is a value in the Sort Parameters quadrant for HAZE AVG. TOTAL or HAZE REGION. Data at the points where the haze is far above average will be inaccurate.

Please Initialize New Cassette

Displayed when a receiver cassette is full and wafer should be unloaded or when the sender cassette is empty and a wafer should be fetched. *Initialization* is optional but *loading* is necessary to continue operation.

Plotting in Progress

Surfscan is busy processing wafer data of too many particles.

PMT Disabled

Displayed while the parameter value for MAX SIZE is 0.00 or whenever there is a Photomultiplier Tube (PMT) overload. The wafer is always rejected if this message appears during a scan.

Press [HOME] to End [START] to Continue

Suggests keys to press after the scan was stopped.

Printer Disconnected

Appears if the printer is not connected when data is ready to be transmitted (using [PRINT] or with AUTOPRINT ON). After connecting the printer, press [PRINT].

Printing in Progress

Processor is unable to execute commands until printing is complete. However, it will "remember" commands and carry them out as soon as the printing is complete.

Remove Cassette – 1WFR mode

Menu transfer mode is set for 1WFR mode, but there is a cassette on the sender indexer.

Replot Disabled (Change in menu)

Since Data Collection parameters have been changed, data from the previous scan cannot be replotted. To obtain data with the new parameters, scan or rescan wafer.

Self—Test in Progress

Displayed if [HOME], [START], or [CASS] is pressed before self-tests are done when the Surfscan 4500 is powered up. If this message is displayed for an extended period (longer than a minute), press the system reset button located on the left side I/O panel.

Wrong I/O Modules

Call Tencor Instruments' Service Department.

4.2 STATUS DISPLAY CODES

A parameter in the system configuration quadrant of the MENU can be set to display status messages on the monitor. Status codes are useful during in-depth troubleshooting. Normally, the STATUS DISPLAY parameter is OFF, but it can be set to ON or TEST.

OFF

The normal value for this parameter, OFF leaves the area for status codes blank. Unless an instrument error is suspected, leave the status display off.

ON

If the parameter STATUS DISPLAY is set to ON, the Data Display includes codes which describe the internal machine operations. These codes appear in the bottom left corner of the Data Display, below the message window. The codes are arranged in lines, with each line pertaining to a type of operation. This feature is not intended for your use; Tencor Instruments' Service Engineers will refer to it when needed.

TEST

Compared to STATUS DISPLAY = ON, this uses more of the Data Display to provide test messages. While the value TEST is selected, the Histogram cursors are not displayed because the white "plane" of the monitor is reserved in the plot area for the test messages. This feature is not intended for your use; Tencor Instruments' Service Engineers will refer to it when needed.

Be sure to leave STATUS DISPLAY at OFF or ON or else the Histogram cursors cannot be used.

4.3 PURGING SYSTEM WITH HEPA FILTER

After installing, servicing or moving the Surfscan 4500, the HEPA filter should be run to purge the system of airborne particles. The HEPA filter also be run whenever the unit is being operated in an environment less than class 100.

Turn on the HEPA Filter circulating fan by pressing [HEPA]. Check that the Functions Line of the Data Display says "HEPA".

4.4 CLEANING THE PUCK

Coated with a special contamination-resistant surface, the puck may be cleaned using a cleanroom wipe and methyl alcohol. The surface has a Teflon™ coating; any safe solvents for this substance can be used for cleaning. The puck should not require regular cleaning unless gross contaminants have been transferred to it from the bottoms of wafers during handling.

Methyl Alcohol (Methanol) is highly flammable and poisonous. Fumes should be removed by adequate ventilation while using.

❶ With no cassette on the Sender/Indexer and TRANSFER MODE = 1WFR, press [START] to bring the puck out to the *One-Wafer mode* load/unload position. Check that vacuum is not being drawn into the ports on the puck – if vacuum is making a hissing sound, wait until it stops.

❷ Dampen a cleanroom wipe with methyl alcohol (excess alcohol might drain into the vacuum control system if the wipe is dripping wet).

❸ Rub the wipe over the top and edges of the puck. Dry it with a fresh wipe and allow any remaining alcohol to evaporate for one minute or longer.

❹ Press [HOME] to send the puck home.

4.5 REPLACING INSTRUMENT FUSES

If the printer, keyboard power LED or monitor turn off while the Surfscan 4500 is being used, the problem may be a blown fuse in the power receptacle on the left side panel. There are two fuses in this fuse block. One or both may need replacing if the Surfscan 4500 is not working.

❶ Turn off the Surfscan 4500 power.

❷ Disconnect the Surfscan 4500 line cord from the power receptacle.

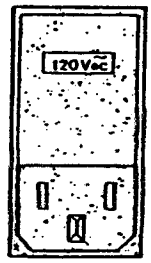

Figure 21: Fuse Cover

3. Carefully pry open the fuse cover with a small screwdriver under the tab at the top.
4. Slide out both fuse holder inserts.

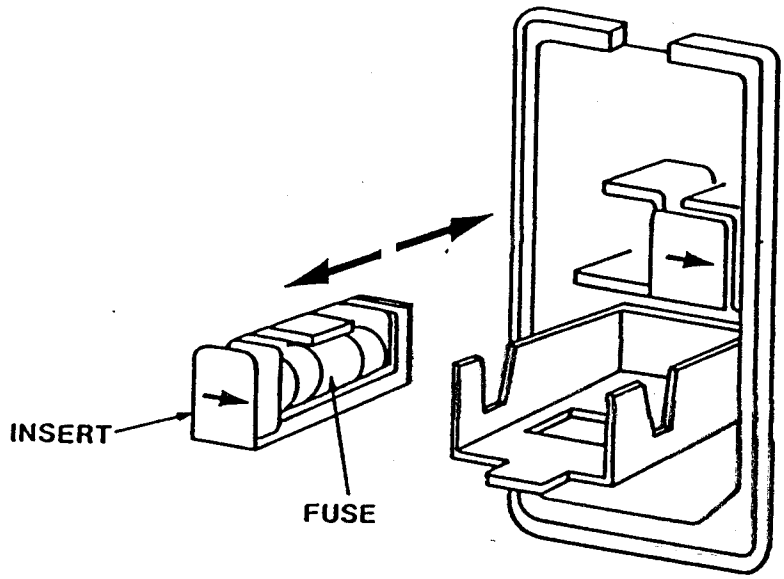

Figure 22: Fuse Holder Inserts

❺ Replace each blown fuse with a new one of the proper rating.

Use 2 Ampere slow-blow for 220 VAC and 240 VAC.

or

Use 5 Ampere slow-blow for 100 VAC and 117 VAC.

❻ With the arrows pointing to the right, reinstall the fuse holder inserts.

❼ Close the fuse cover and press until it snaps shut.

❽ Connect the line cord to the power receptacle and turn on the power.

REPLACING MONITOR OUTLET FUSE

To preserve the lifespan of CRT, the Surfscan 4500 blanks out the monitor after several minutes of inactivity. It may be renewed by pressing any key (such as [HELP] or [MENU]). If the Surfscan 4500 is working but the monitor is blank, the problem may be a blown monitor fuse.

❶ Turn off the Surfscan 4500 power.

❷ Disconnect the Surfscan 4500 power cord from the utility outlet.

❸ The monitor power fuseholder is mounted next to the monitor power outlet. Remove the fuse cover by turning counterclockwise. Remove and replace fuse with:

One fuse – 2-Ampere slow-blow, 117 VAC

❹ Replace the fuse cover, plug in the Surfscan 4500 power cord, and power up.

If this does not fix the problem, start at Step 1 again and check the fuseholder on the rear chassis of the monitor (open the monitor's rear cover). This 3-Ampere fuse should not blow before the monitor outlet power fuse does.

REPLACING PRINTER OUTLET FUSE

❶ Turn off the Surfscan 4500 power.

❷ Disconnect the Surfscan 4500 power cord from the utility outlet.

❸ The Printer Outlet fuse holder is mounted above the power outlet. Remove the fuse cover by turning counterclockwise. Remove and replace fuse with:

One fuse – 1-Ampere slow-blow, 117 VAC

❹ Replace the fuse cover, plug in the Surfscan 4500 power cord, and power up.

❺ If this does not fix the problem, replace the printer internal fuse.

REPLACING PRINTER INTERNAL FUSE

If the 20-column printer's power LED is OFF even though it is plugged in, its internal fuse may need replacing.

❶ Turn off the Surfscan 4500 and unplug the printer power cable and signal cable.

❷ Remove the four screws that hold the bottom cover to the printer case. Lift the printer case at the back to separate the two parts.

❸ Install a 1/4 Ampere, 125 VAC slow-blow fuse.

❹ Replace the printer case. Add the four screws to attach the bottom cover.

❺ Reconnect the signal cable. Connect the printer power cord.

❻ Power up the Surfscan 4500.

4.6 CHANGING INSTRUMENT VOLTAGE SELECTOR

If the Surfscan 4500 is moved to a site having a different rating of AC power, its voltage selector must be switched. If the power change is between 100 VAC and 117 VAC or 220 VAC and 240 VAC, then the Surfscan 4500 power cord must be also be replaced (contact Tencor Instruments' Sales Department).

Because the monitor and printer draw power from the instrument's power outlets (conditioned by the Surfscan 4500), changing the voltage selector (and replacing the cord for 100-117 to 220-240) is the only adjustment necessary for the Surfscan 4500.

TO CHANGE:	ACTION:
from 100 VAC to 117 VAC from 117 VAC to 100 VAC	Remove and Rotate selector
from 220 VAC to 240 VAC from 240 VAC to 220 VAC	Remove and Rotate selector.
from 110/117 to 220/240 from 220/240 to 110/117	1)Rotate selector. 2)Replace Surfscan 4500 line cord. 3)Replace fuses.

The voltage selector is not a thumbwheel switch. It is a cam which must be removed, rotated to select the voltage, and reinserted.

❶ Turn the Surfscan 4500 power switch OFF.

❷ Disconnect the Surfscan 4500 power cord from the power receptacle.

❸ Carefully pry open the fuse cover with a small screwdriver under the tab at the top.

❹ Remove the voltage selector.

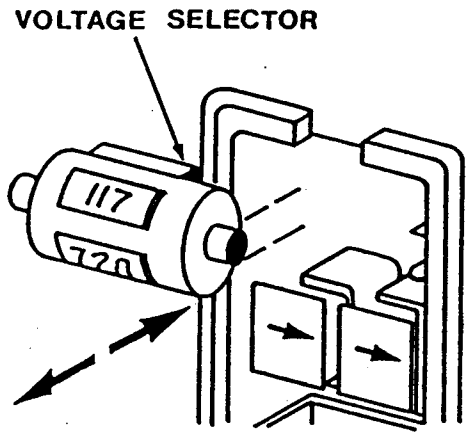

Figure 23: Changing Instrument Voltage Selector

❺ Measure the utility outlet voltage with an AC voltmeter to verify the correct value for the voltage selector (refer to the operating specifications for voltage tolerances).

❻ Rotate the voltage selector so the correct value faces outward when reinserted.

❼ Slide the voltage selector back into the slot. If upside down, it will not fit. It must be inserted completely.

Rotation of the voltage selector without removing it will damage the assembly

❽ Check that the correct fuses for the line voltage are installed.

❾ Close the fuse cover and press until it snaps shut.

The line cord must be connected to a grounded outlet while the instrument is in use to prevent possible electric shock from the metal chassis. Check the ground connection before plugging the line cord into an outlet.

❿ Connect the line cord (either the new one or the old one, depending on the outlet type at the new location) to the power receptacle.

⓫ Turn on the power.

4.7 REPLACING PRINTER PAPER

The standard 20-column printer uses thermal paper available from Tencor Instruments. Replace it with the same type or equivalent to ensure proper print intensity. Use cleanroom paper if the printer is being operated in the cleanroom area – normal paper releases many particles that affect cleanroom processes. The following procedure pertains only to the 20-column printer. For instructions for an 80-column printer, refer to its user's manual.

Because the printer does not detect whether the paper has run out, check it periodically. DO NOT operate the printer if the paper is not advancing or if it is out of paper.

Paper used in the printer is electrically conductive. Do not replace paper with the printer power cord plugged in.

❶ Unplug the printer cord.

❷ Turn the paper advance thumbwheel toward the rear of the printer to remove all paper from the old roll. NEVER insert new paper into the printhead until all of the old paper is removed.

❸ Remove the paper spindle and slide it into the new roll of paper.

4. Push the beginning of the paper roll into Slot A while turning the paper advance thumbwheel. Continue advancing the paper through Slot B until it is past the tear bar/window. Tear off the excess paper.

5. Plug in the printer power cord.

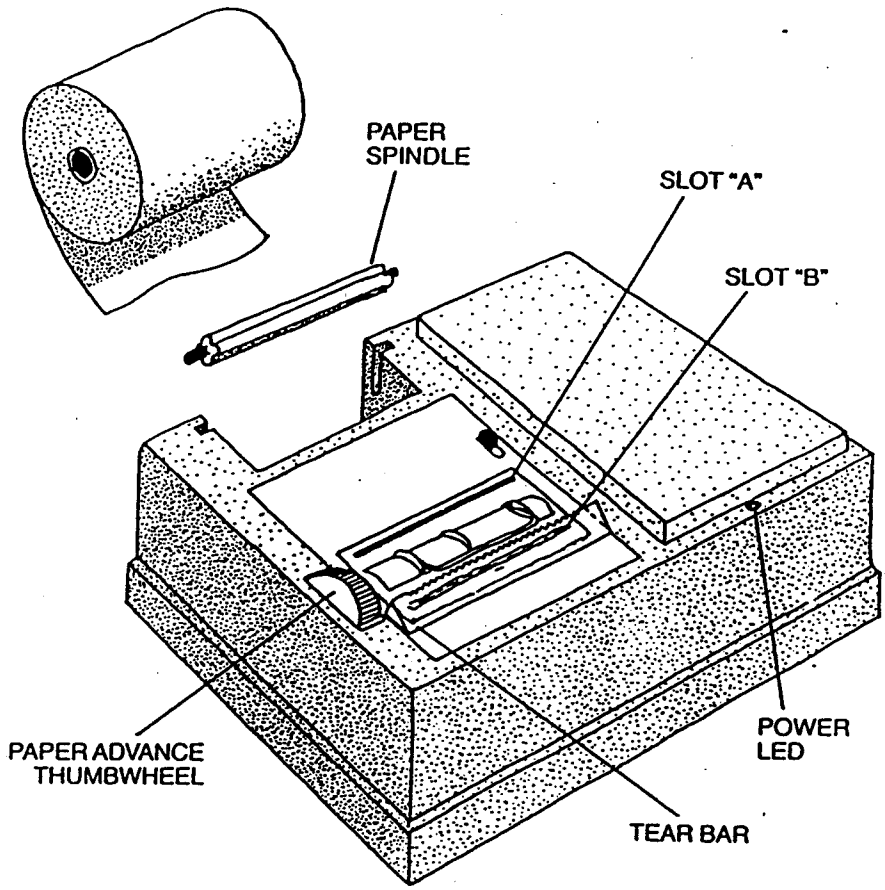

Figure 24: Loading Printer Paper

4.8 PACKING FOR SHIPPING OR MOVING

If the Surfscan 4500 must be moved or shipped, review the instructions in *INSTALLATION* before continuing here.

If the original crate has been lost or damaged, contact Tencor Instruments' Service Department for a replacement. A Tencor Instruments crate must be used for correct support during transportation or the Surfscan 4500 may be damaged during shipping.

❶ Turn off power and disconnect all cables.

❷ Disconnect the vacuum line. Plug the line from the facility to prevent draining the vacuum supply. Plug the vacuum line connector on the Surfscan 4500 to prevent contamination.

❸ Remove the monitor from the top of the scan unit.

❹ To protect the optics from contamination, cut a piece of plastic to 2-1/2 x 9-inch and tape it over the scan port (on the transporter side of the scan housing). (You may wish to clean it by spraying it with compressed nitrogen before attaching it.)

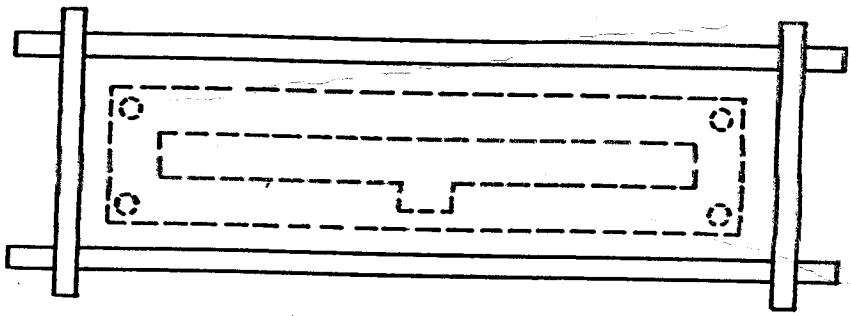

Figure 25: Covering Scan Port

❺ Seal the entire Surfscan 4500 (without monitor) with plastic sheeting, taping all seams to prevent contamination due to dust.

❻ Gently lift the Surfscan 4500 into the shipping crate, being careful not to lift from the transporter end.

❼ Pack the rest of the system in the shipping crate.

4.9 SWITCHING LOCATOR BLOCKS

Locator blocks hold the cassettes in place on the indexer platform, The locator blocks must be switched when changing cassette series between Fluoroware™ Series PA-72 and PA-182 or vice-versa as shown below.

Locator blocks can be easily switched without any adjustments, in most cases. Call Tencor Instruments' Service Department if switching blocks causes fetching or unloading problems.

❶ Remove cassette and allow indexer platform to rise and tilt back.

❷ With a hex-key wrench, loosen the bolt in the middle of the block until it can be lifted up to clear the dowel pins. Slide the assembly toward the center of the transporter and lift clear.

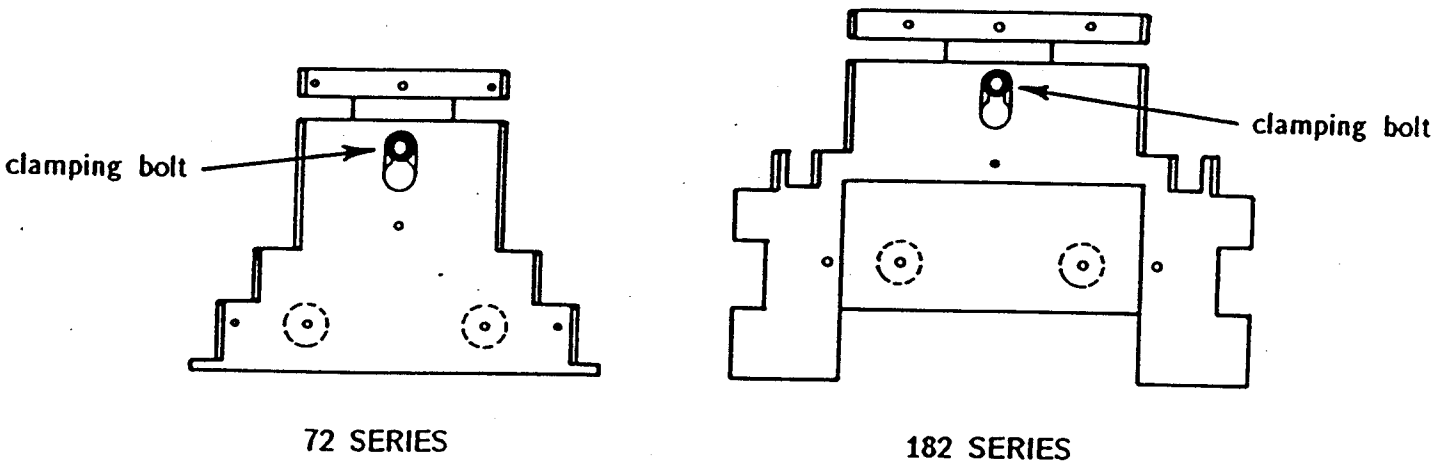

Figure 26: Types of Locator Blocks

❸ Set the replacement locator block in place and tighten the clamping bolt.

❹ Repeat for any remaining indexers.

APPENDIX 1 – OPTIONS AND ACCESSORIES

model # :	Description
70-01510	SECS II Interface
70-01100	Fluoroware™ PA-72 Series Cassette Locator Blocks for 3-inch, 100 mm (4-inch), 125 mm (5-inch) wafers.
70-01110	Fluoroware™ PA-182 Series Cassette Locator Blocks for 100 mm (4-inch), 125 mm (5-inch), and 150 mm (6-inch) wafers.
70-01090	Additional receiver indexer. One maximum add-on capability to configure as Three-indexer.
70-01530	Surfscan 4500 User's Manual (Not for cleanroom use).
70-01540	Surfscan 4500 Cleanroom User's Manual (Meets Class 100 cleanroom requirements).
70-00491	Thermal printer paper (non-cleanroom) for standard 20-column printer.
70-00640	Cleanroom thermal printer paper (Lint free) for standard 20-column printer.
SCS-1402	Surface Contamination Standard, 100mm. Silicon wafer with specific scattering sites etched into the surface. For use as a working standard and count standard.
SCS-1402S	Surface Contamination Standard Set, 100mm. Includes 4 absolute standards (0.364μm, 1.09μm, 2.02μm and 4.0μm) plus an SCS-1402.

See Chart Absolute Contamination Size Standard. Silicon wafer with calibrated latex spheres deposited on the surface. Includes Certificate of Calibration and Documentation.

Wafer Diameter	4.0μm	2.02μm	1.091μm	0.500μm	0.36μm	0.269μm
100mm	Model # ACS1421	Model # ACS1422	Model # ACS1423	Model # ACS1424	Model # ACS1425	Model # ACS142(
125mm	Model # ACS1521	Model # ACS1522	Model # ACS1523	Model # ACS1524	Model # ACS1525	Model # ACS152(
150mm	Model # ACS1621	Model # ACS1622	Model # ACS1623	Model # ACS1624	Model # ACS1625	Model # ACS162(

INDEX

TENCOR INSTRUMENTS SERVICE POLICY

The Tencor Instruments Service Organization is at your service in the United States, Europe and Japan. We are also represented in Korea, The People's Republic of China, Taiwan, Hong Kong, Singapore and India. The office for you to call is listed in the following "Sales and Service" pages.

The company objective is to provide a technical response by telephone within 24 hours, oftentimes within the same business day. The objective for on-site repair is 48 hours.

- In the United States, you should call (800) 722-6775 which operates Monday through Friday from 6:00 a.m. to 6:00 p.m. Pacific Time. All service activities are dispatched from this central number in California.
- Normal service hours are Monday through Friday, 8 a.m. to 5 p.m. Pacific Time. A different time coverage can be provided by a customized service contract.
- Service beyond the original warranty period is typically provided on an as-needed basis. All repair work is then warranted for three months. Full service contracts provide an extension of the warranty period. They can be customized to your specific requirements.
- If time-to-repair is not highly critical, you may find it economically advantageous to send your instrument to a Tencor Service Depot. The company objective is to return it to you within two weeks.

You are encouraged to attend a maintenance and repair training course specific to your instrument. In general we find that the better trained users experience better instrument up-time and take advantage of our service resources. The course and fee schedule may be obtained from your sales or service engineer.