CHAPTER 2

SYSTEM SPECIFICATIONS and GENERAL DESCRIPTION

2.1 INTRODUCTION

This section provides specifications, system features, and a physical description of the WaferMark® *SigmaClean* and *SigmaClean300* system. Where necessary, any variance between system styles will be indicated accordingly.

2.2 GENERAL SYSTEM FEATURES

The WaferMark® *SigmaClean* is a laser-based marking system specifically designed to mark silicon wafers in a production environment, with cleanroom quality. There are two styles of system – the standard WaferMark® *SigmaClean* and the WaferMark® *SigmaClean300.* The standard system is capable of marking a range of different wafer sizes, while the *SigmaClean300* system allows marking on 200 and 300 mm wafers.

Unless otherwise noted, the following features are standard on WaferMark® *SigmaClean* systems:

- Acousto-optic, Q-switched, TEMoo, Nd: YLF diode-pumped, water cooled laser.
- Closed-loop power stabilization circuitry for consistent laser power output.
- ULPA air filtration system to trap particulate matter for debris-free marking.
- A wafer handling system utilizing a precision robotic wafer handler and a three-cassette presenter (two-cassette presenter on the WaferMark® *SigmaClean300* system).
- Marking with multiple fonts over a wide range of wafer sizes (200 and 300 mm wafer size capability only, on the WaferMark® *SigmaClean300* system).
- Interactive operator workstation with monitor and keyboard for marking control, and display of system status and fault conditions.
- Unattended operation with high-volume throughput.

2.3 SYSTEM CONFIGURATION

The system consists of a Handler/Control cabinet, only.

The system is designed to operate in a Class I cleanroom environment and can be configured as either a bulkhead-mounted unit with rear and side access, or as an island unit within the environment.

accordance with SEMI M12-92 specification for alphanumeric marking on the front surface of polished silicon wafers.

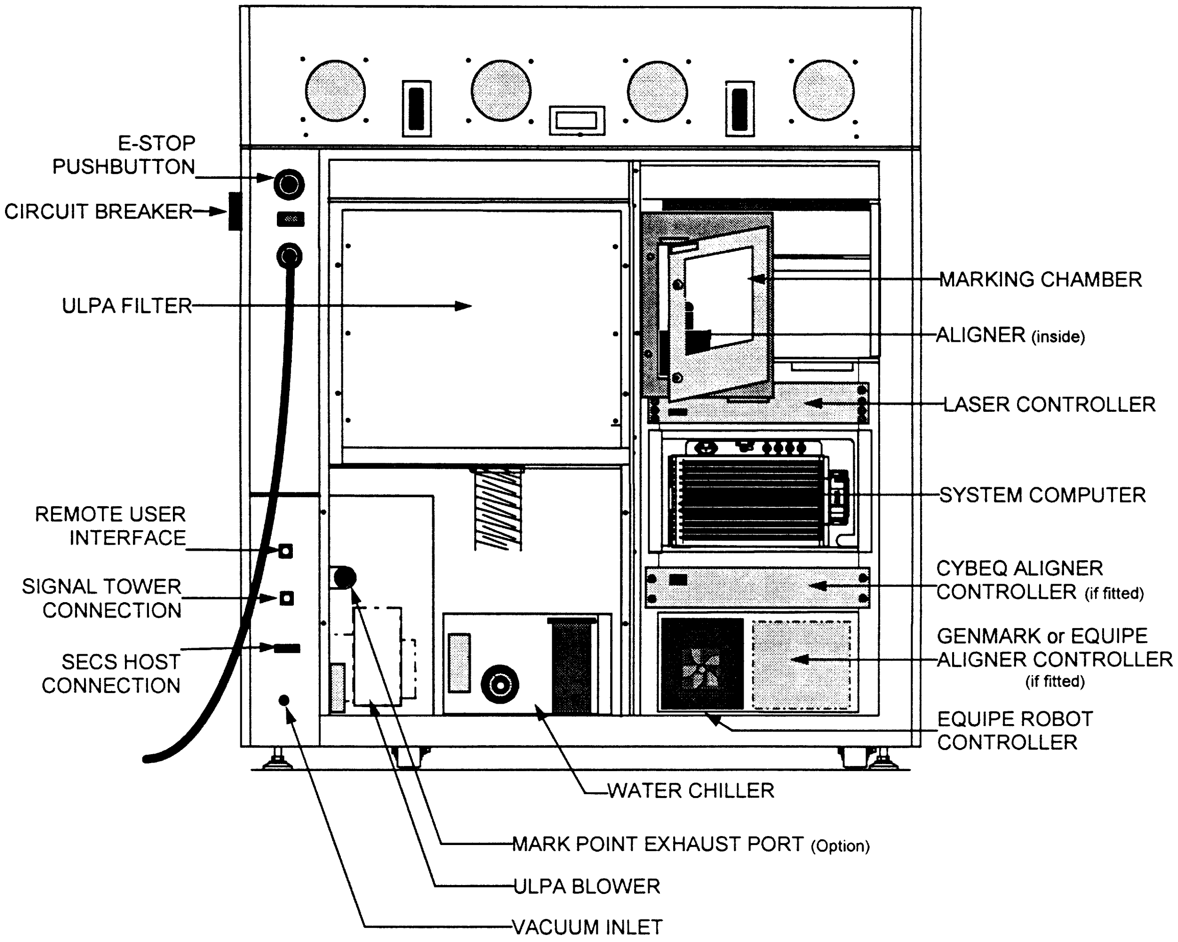

Figure 2-2. Handler/Control Cabinet — Rear View

An optional system design allows for outboard presenters which can be rotated toward the front of the system to allow automatic wafer material transportation systems to access the cassettes, in accordance with SEMI specification E15-91 for inter-equipment material transport interface.

The WaferMark *SigmaClean* can also be optionally modified to accommodate customer supplied Standard Mechanical Interface (SMIF) loading equipment and mini-environments. A wall-mount cover is also available to provide through-the-wall installation of the system, with access from the service chase for maintenance activity.

WaferMark® *SigmaClean300* System

The handler components installed in the *SigmaClean300* system consist of two fixed-position load/unload cassette presenters, a Hine robot with dual end effectors, and a marking chamber containing an integrated (Vision) aligner and aligner controller, capable of handling 200 and 300 mm wafers.

External sources of vacuum, exhaust, and single phase power are required. (For power requirements, see Utilities in table 2-1.)

2.4 SYSTEM SPECIFICATIONS

The system specifications for the WaferMark® *SigmaClean* and *SigmaClean*300 are shown in the following table.

Table 2-1. WaferMark® *SigmaClean* and *SigmaClean300* System Specifications

MARKING PERFORMANCE	
Fonts:	SEMI OCR, BC412, and other Dot Matrix formats available.
Position:	Multiple mark groups at any orientation on the wafer front surface, within a 25 mm band around the wafer circumference.
Process:	
SuperSoftMark®	Debris free
Dot Diameter	70 µm ± 10 µm
Dot Roundness	Major to minor axis ratio less than 1:1
Dot Depth	2.6 µm ± 0.4 µm
Throughput:	
Single pulse, 5 x 9 dot matrix, 18 characters	240 wafers/hour
Single pulse, 10 x 18 dot matrix, 18 characters	170 wafers/hour
Process particle density mean	<0.02 per cm^2 (with mark contained within a 5 mm cylindrical band)
Minimum character size for debris-free marking:	
5 x 9 single density	1.1 mm high x 0.55 mm wide
10 x 18 double density	2.2 mm high x 1.1 mm wide
WAFER HANDLING	
Wafer Size Range:	SigmaClean: 100, 125, 150, and 200 mm (4-, 5-, 6-, and 8-inch) SigmaClean300: 200 and 300 mm (8-inch and 12-inch)
Alignment:	Optical alignment over the entire wafer size range with no hardware change-over for both flatted and notched wafers.
Repeatability:	± 125 µm (±.005 inches) in both X and Y axes relative to the primary fiducial.
Wafer Transporter:	Pick-and-place robotic arm with dual vacuum wand.
Throughput:	Up to 240 wafers per hour (single pulse marking, per SEMI specification M12-92).
Sense and Receive Modules:	Three load/unload cassette stations capable of performing no work-over- work handling. Movable Presenters for AGV access per SEMI specification E15-91 (optional)

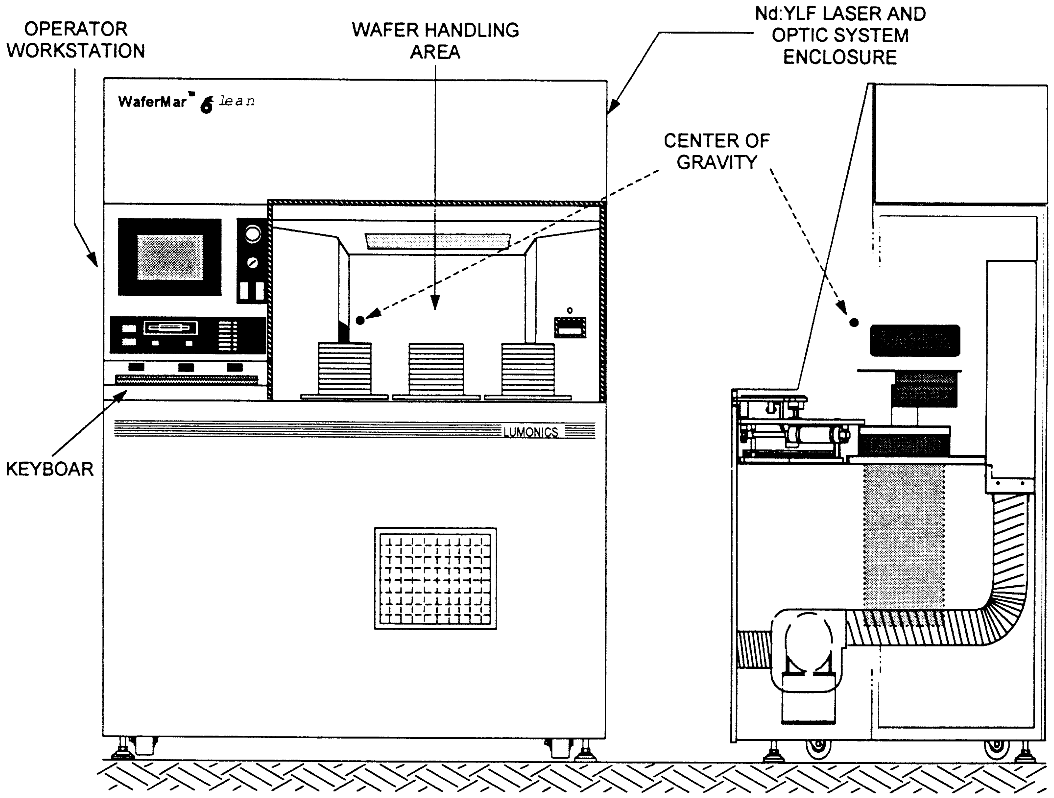

Figure 2-1. Handler/Control Cabinet — Front and Side Views

2.6 OPERATOR WORKSTATION

The operator workstation, shown in Figure 2-1, is located at the front, left-hand side of the Handler/Control cabinet. The workstation is the means by which marking jobs are started, monitored, and terminated. From this position the operator can initiate, control, and monitor the complete marking process. The workstation consists of a monitor, keyboard, floppy disk drive, keyswitch panel, and status panel. The switches on the status panel control wafer loading and laser operation, while the indicators monitor the primary system functions for abnormal conditions or failures.

2.7 WAFER HANDLING SYSTEM

The robotic wafer handling system automatically draws wafers from cassettes, positions then for marking, then returns the wafers to cassettes after marking has occurred. Major components are the cassette presenters, robot, and wafer aligner. The wafer aligner is located in the marking chamber behind the chamber safety door.

Standard WaferMark® *SigmaClean* System

The standard WaferMark® *SigmaClean* system contains three fixed-position load/unload cassette presenters that are accessed by a dual-wand radial arm robot. The robot delivers wafers to the optical aligner. This non-contact aligner uses a CCD array to scan the wafer perimeter. It locates the fiducial, flat or notch, then centers and positions the wafer under the mark point, to within ±200 mm accuracy. The aligner is capable of positioning wafers sizes between 100 mm and 200 mm for marking anywhere on the wafer front surface within a 25 mm band of the circumference. The wafer handling system can process 240 wafers per hour in the SuperSoftMark™ mode, in

Table 2-1. WaferMark® *SigmaClean* and *SigmaClean300* Specifications (continued)

LASER AND OPTICS

Laser Type:	Acousto-optic, Q-switched, TEMoo, Nd: YLF diode-pumped laser Maximum Output: 4 Watts Pulse Duration: CW/50 ns Wavelength: 1053 nm
Optics:	Flat field focusing lens

WORKSTATION

Control System:	MS-DOS-based control unit with 3½–inch floppy drive and hard disk drive for storage of all system parameters
Software:	Operator prompt, pull-down menu format using a flat panel monitor and full-size keyboard. Bar code wedge reader input device optional
Diagnostics:	Complete system diagnostic indicators displayed on front panel, along with the E-STOP button and system keyswitch. Automatic laser data logging function
Communication:	SECS II / GEM interface optional
Cleanroom Rating:	Class I compatible stainless steel cabinet with integrated ULPA filter unit. Stand-alone configuration standard; wall mount optional

UTILITIES

Electrical:	Standard connections: 200 VAC, single phase, 50/60 Hz, 24 FLA 208 VAC, single phase, 50/60 Hz, 23 FLA 220 VAC, single phase, 50/60 Hz, 22 FLA Optional connections: 400 VAC, single phase, 50/60 Hz, 12 FLA 416 VAC, single phase, 50/60 Hz, 12 FLA System Circuit Breaker Rating: 18000 AIC @ 240 VAC 14000 AIC @ 480 VAC
Vacuum:	63.5–76.2 cm (25–30 inches) Hg at 2 SCFM (635–762 mm/Hg at 56.6 L/min) ¼-inch diameter press-lock connection
Exhaust:	20 CFM (560 L/min) flow rate (maximum) 32 mm (1.25 in) diameter port

Table 2-1. WaferMark® *SigmaClean* and *SigmaClean300* Specifications (continued)

DIMENSIONS			
Physical Dimensions:	1626 mm H x 978 mm W x 1461 mm D (64 in x 38.5 in x 57.5 in)		
Weight:	637 kg (1405 lb)		
Load Distribution:	Right Front Foot	393 lb/ 178 kg	(28%)
	Left Front Foot	464 lb/ 210 kg	(33%)
	Right Rear Foot	351 lb/ 159 kg	(25%)
	Left Rear Foot	197 lb/ 89 kg	(14%)
Center of Gravity:	See Figure 2-1 and Drawing No. 2850114 (Center of Gravity Location)		

SYSTEM OPTIONS INCLUDED:

- Empty Slot Detection
- Anti-Static Package
- Status Indicator Tower 3-light
- Wafer Handling Edge Gripping

SYSTEM OPTIONS AVAILABLE:

- SECSII/GEM Interface
- High Speed Messaging System (HSMS). Consult Factory.
- Status Indicator Tower 4-light
- Bar Code Wedge Reader
- Cassette Bar Code Reader
- WaferTrace® Mark Verification System and Dot-by-Dot System
- Bulkhead Mount, Cover Panels
- Dual Spot Optics
- Moveable Presenter
- Leak Detector
- Vacuum Gauge (front mount)
- Membrane Keyboard (stainless steel or painted)
- Seismic Tie-Down Package
- EMO Guard
- UPS (computer electronics only)

2.5 HANDLER/CONTROL CABINET PHYSICAL DESCRIPTION

The Handler/Control stainless steel cabinet is illustrated in Figures 2-1 and 2-2. The cabinet contains all components and modules required to perform wafer marking. These components include the laser and optics system, wafer handling system, operator workstation, system computer and dedicated electronic controllers. Other self-contained units include a chiller, ULPA filter, and control electronics.

The laser used in this system is an ultra-stable, Lumonics Sigma 100 diode-pumped Nd:YLF laser which generates and delivers the laser beam to the enclosed marking chamber. The system uses high performance galvanometer beam positioners to steer the beam across the wafer surface, under control of the system computer.

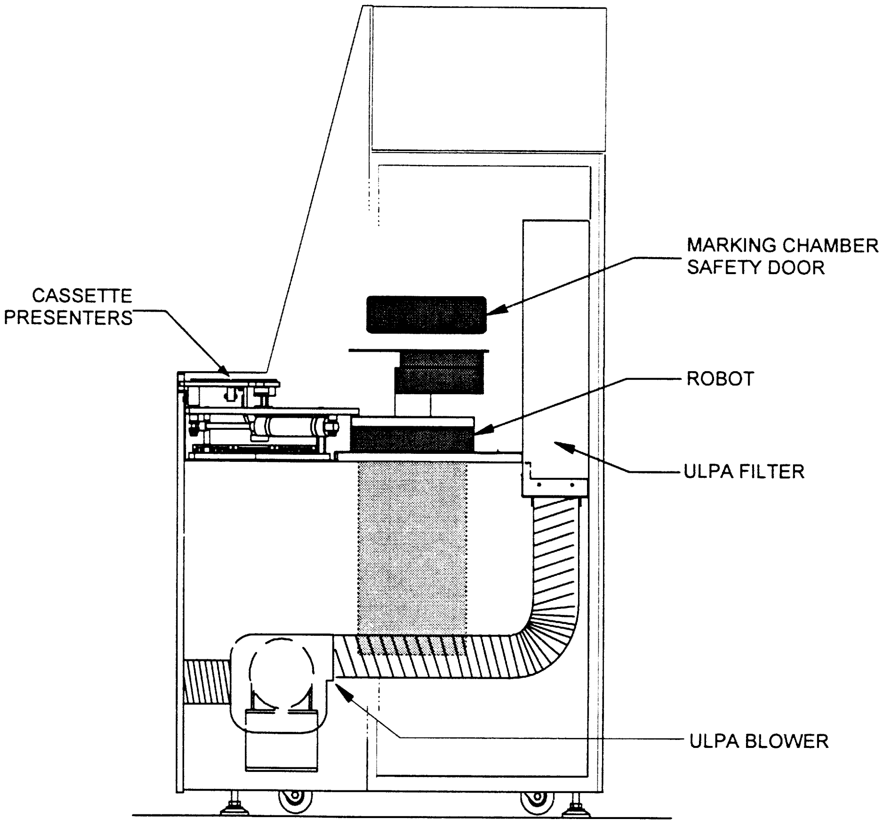

Figure 2-3. Wafer Handling System—Cross-Sectional View

2.8 SYSTEM COMPUTER AND CONTROLLERS

The system computer and dedicated electronic controllers are housed in the electronics maintenance bay which is located directly behind the operator workstation. Entry to the bay is through a maintenance door at the rear, right-hand side of the Handler/Control cabinet, which provides access to the following components:

Robot and Aligner Controllers—These two controllers govern wafer manipulation and alignment during marking. The robot controller controls the robot to accomplish the necessary manipulation of wafers. The aligner controller controls the marking chamber aligner which positions wafers before marking. Both units are mounted within the electronics maintenance bay. (Their actual mounting location in the bay is determined by which model of controller is installed—either Equipe Technologies, Genmark, or Cybeq.)

Marking Chamber—An entry door inside the electronics maintenance bay provides access to the aligner and interior of the marking chamber. The door is fitted with a special glass viewing port so that marking can be observed in safety. If this door is inadvertently opened during the marking process, a door interlock will be broken which will halt the marking process and prevent any further transmission of the laser beam to the wafer surface.

Operator Workstation Components—Viewed from the rear of the Handler/Control cabinet, the open area directly above the Laser Controller provides access to components mounted behind the operator workstation. These components include the monitor, keyboard, floppy disk drive, fault display PCB and the load/unload switches.

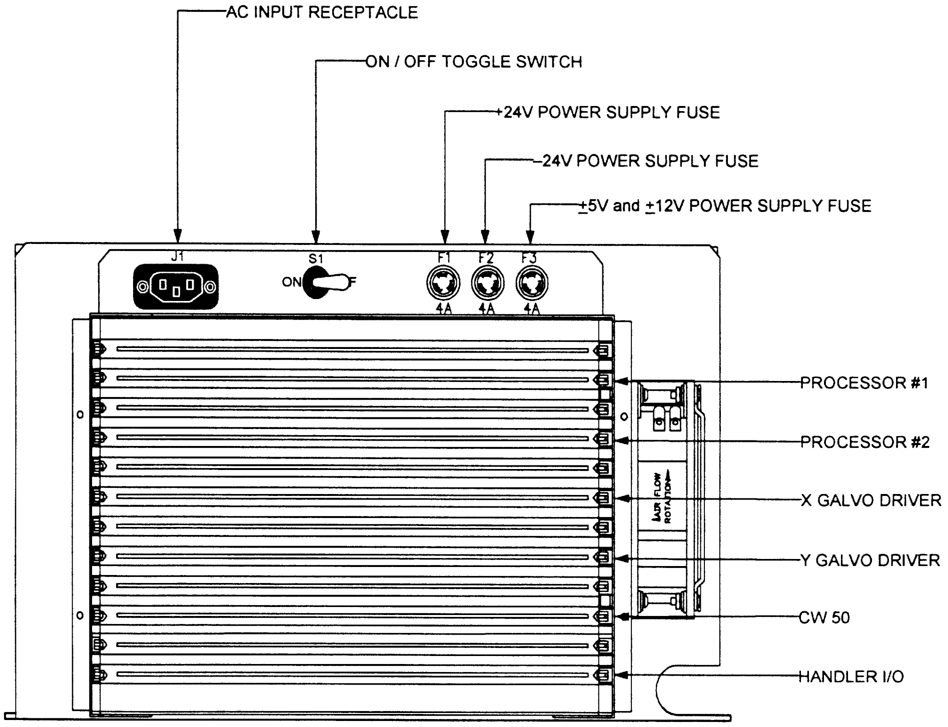

Figure 2-4. System Computer Card Rack

System Marking Computer (Figure 2-4)—The system computer consists of dual (master/slave) microprocessors contained on two printed circuit boards which are housed in a dedicated card rack. An Intel multibus on the backplane of the rack provides electronic interface for the boards. The rack contains fused, modular power supplies and the following printed circuit boards:

- **Processors #1 and #2**—Processor #1 provides user interface and general system control. Processor #2 is dedicated to marking. Each processor has on-board memory and dual RS-232 serial ports.
- **X and Y Galvanometer Drivers**—Converts processor-generated motion data to signals used to drive galvanometric scanners which steer the laser beam across the wafer surface.
- **CW 50**—Generates timing signals to the RF Driver which controls laser firing.
- **Handler I/O**—Provides input/output lines which interface the processors with various system components.

2.9 SIGMA 100 LASER ASSEMBLY

The integrated laser and optic assembly is enclosed within an interlocked compartment at the top of the cabinet. The laser source is a patented Lumonics Sigma 100 diode-pumped, solid-state, Nd:YLF laser. The closed-loop power control design of this infra-red light source provides an ultra-stable energy output capable of producing quality laser marks in cleanroom environments.

The laser system consists of three separate modules:

- Laser Assembly
- Controller
- Chiller

These three modules are interconnected by coolant tubing and by an umbilical assembly made up of electrical cabling.

The heart of the Laser assembly is the pumping chamber, in which two key components are closely coupled—the laser diode bars and the Nd:YLF rod. When the Laser Controller transmits a trigger pulse, the current modulator excites the laser diode bars using a current pulse. The current modulator is capable of supplying current pulses of up to 100 amps peak current for time durations of up to 200 µs. Typically, it will supply a current pulse for 100 µs (called a pumping pulse), and the laser diode bars will emit radiation at 800 nm for a similar time period.

The radiation emitted by the laser diode bars is collected and collimated into the Nd:YLF rod. The rod has several strong absorption bands in the 800 nm region, and the temperature of the bars is carefully adjusted to ensure that the diode radiation is efficiently absorbed in the Nd:YLF rod. Once the Nd ions have absorbed the 800 nm radiation, they are excited to the upper laser level, and produce gain in the 1 µm region. In a conventional laser cavity, this gain would result in laser output at 1 µm for nearly the full 100 µs duration of the pumping pulse. This mode of operation is generally called *fixed-Q*.

However, the Sigma-100 laser cavity consists of the pumping chamber and an acousto-optic Q-Switch in addition to two optic mirrors: one highly reflective back mirror and a partially-transmitting output mirror. The Q-Switch is used to prevent 1 µm radiation from building up in the laser cavity during the 100 µs pumping pulse. At the end of the pumping pulse, the Q-Switch is switched from a non-transmitting state to a transmitting state. The 1 µm radiation builds up very quickly and a laser pulse of 1 to 2 mJ of energy and a duration of approximately 100 ns is emitted. This mode of operation is generally called *Q-switched*.

The Sigma-100 will accept trigger pulses at any repetition rate up to 1000 pps. After each trigger pulse, there is a programmable delay of approximately 300 µs before the emission of the Q-switched pulse. To ensure that the laser diode bars and the Nd:YLF rod are adequately cooled at this repetition rate, a closed-cycle chiller circulates coolant through the pumping chamber. The excess heat is removed from the chiller by a water-to-air heat exchanger. The controller uses a heater and temperature sensor to maintain the coolant temperature within the optimal operating temperature range.

All of the control electronics, power supplies and power distribution system are mounted in the Laser Controller module, except for the current modulator, which is mounted on the Laser assembly. The microprocessor-based Controller handles all of the timing and calibration issues, the decision-making, the interlocks and warnings, the temperature control and laser energy control, and all the data-logging features.

2.10 CHILLER ASSEMBLY

The closed-loop chiller is mounted on the base of the Handler/Control cabinet. It can be accessed by removing the left panel at the rear of the cabinet.

The chiller has two functions:

- To maintain the laser diodes at a constant temperature of 34°C ±0.5°C (93.2°F ±0.9°F).
- To remove excess heat from the current modulator, the laser diode module, the Q-Switch, and the Nd:YLF crystal.

The coolant circulates along the following pathway through the system:

- Chiller pump
- Chiller particle filter
- Laser assembly pumping chamber
- Laser assembly Q-Switch and laser rod
- Laser assembly current modulator
- Chiller flow sensor
- Chiller heat exchanger
- Chiller reservoir
- Chiller pump

A pressure relief valve is located on the pump to protect the system from excess pressure. The chiller is also equipped with a drip tray.

2.10.1 Spill Prevention Feature

The WaferMark system contains the following two spill prevention features:

- Coolant reservoir low level sensor — A sensor mounted in the reservoir detects the loss of coolant below an acceptable limit. The sensor will activate if a leakage occurs in the cooling system, causing the coolant level to drop.
- Secondary containment — Drip pans are located under the Laser assembly and in the area beneath the base of the chiller unit, for secondary containment resulting from a major spill or leak. The cooling hoses between the laser and the chiller are also enclosed in ducts so that a break in a hose will cause the coolant to flow back to the base of the chiller, and thence, through an opening into the drip pan below. Access to the drain plug in the drip pan can be gained by removing the cover plate near the base of the chiller. The capacity of the drip pan under the Laser assembly is 5.8 liters, and for the one in the base, the capacity is 10.0 liters.

A spill of 400 ml (0.1 U.S. gallons) or small leak from the cooling system will eventually cause the low level sensor to activate as the fluid drains away. This will generate a low coolant level signal and thus cause an automatic shutdown. The shutdown stops any further processing, turns off the laser and chiller, and produces an error message which is displayed on the operator screen. Note that a larger leak will be sensed immediately by a flow sensor, which will also turn off the laser and chiller, and set an alarm condition on the Operator Panel.

2.11 POWER DISTRIBUTION PANEL

Power is distributed throughout the system from a central source, known as the Power Distribution Panel (PDP). This panel, which is shown in Figure 2-5, is mounted on the right-hand side of the Handler/Control cabinet (viewed from the front), and can be accessed by removing the panel on the right-hand side of the cabinet. The PDP contains the following major components:

AC input terminal strip—The strip distributes AC power to the electronics bay, fluorescent light and ULPA blower.

EMI filter—The filter provides filtered power to the robot and aligner controllers, system marking computer, and the Laser Controller.

12 VDC Power Supply—Provides power to illuminate the fluorescent light.

24 VDC Power Supply—Supplies power to control relays, interlock circuits, and control circuitry on the system interface board.

Signal Tower light relays and connector—The Signal Tower light relays and connector interface the WaferMark system with optional red, amber, green, and blue lights which allow the operator to visually observe the system operational status.

Vacuum gauge and vacuum sensor—The gauge displays the externally-supplied vacuum pressure. The vacuum sensor signals when the vacuum level is below acceptable limits.

Vacuum solenoids—The adjustable vacuum solenoids drive the presenter and safety door pneumatic cylinders.

2.12 ULPA FILTRATION AND AIR FLOW SYSTEM

The internal air flow system circulates filtered air to keep wafers free of particulates during handling. The system consists of an intake duct on the front of the cabinet, a high volume blower, ULPA filter, intake plenum and exhaust duct.

Air is exhausted from the cabinet through an opening on the base, directly under the transformer casing. On Japanese systems (only), this opening is closed off. Instead, a 4 in duct is connected from an opening at the top of the transformer casing to an exhaust outlet near the bottom of the rear access panel. Lumonics recommends that the material used to connect from the air exhaust at the rear of the cabinet to the external extraction system is 4 in (inside diameter), vinyl-coated, fiberglass duct with steel helical winding; however, metal duct can be used, if preferred. A suggested source for the vinyl/fiberglass duct is McMaster Carr (Number 5501K34)

A mark-point exhaust system can be ordered as an option, depending on the type of wafer material to be marked. Normally, when marking polished silicone wafers, there is no debris generated; therefore, this option should not be required. However, if marking coated wafer material, various by-products will be generated in the marking process. In these cases, the end user must be aware of which by-products will be generated, and take the necessary precautions to filter them.

The mark-point exhaust system which runs from the marking chamber to the outlet at the rear of the Handler/Control cabinet uses a 1¼ in (inside diameter) silicone fiberglass hose (Hi-Tech Hose Inc. Number SF-2). For external connection to the vacuum exhaust system, Lumonics recommends the use of the same material, although metal hose can also be used, if preferred.

The mark-point exhaust external extraction system requires a flow rate of 20 CFM, and vacuum at greater than 2 in of H_2O.

2.13 VACUUM SYSTEM

The externally supplied vacuum is connected to the rear panel of the cabinet. The vacuum line is then routed to the distribution panel for distribution and monitoring.

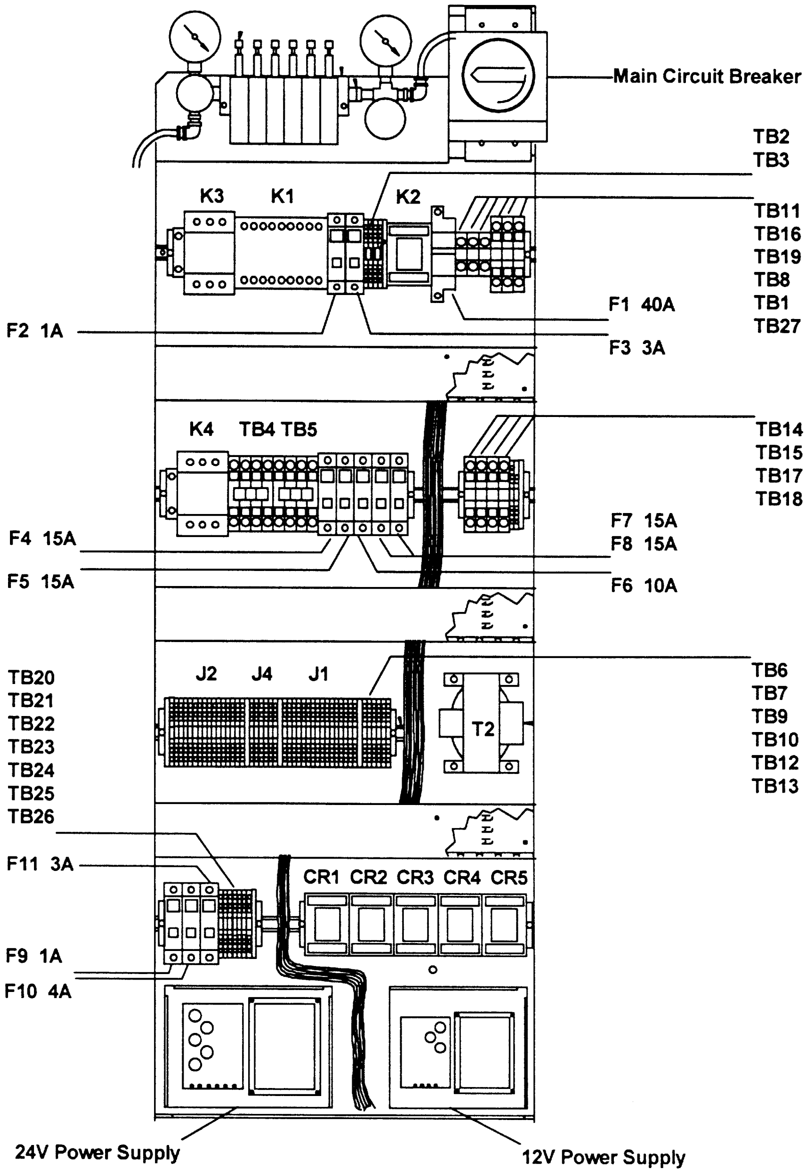

Figure 2-5. Power Distribution Panel

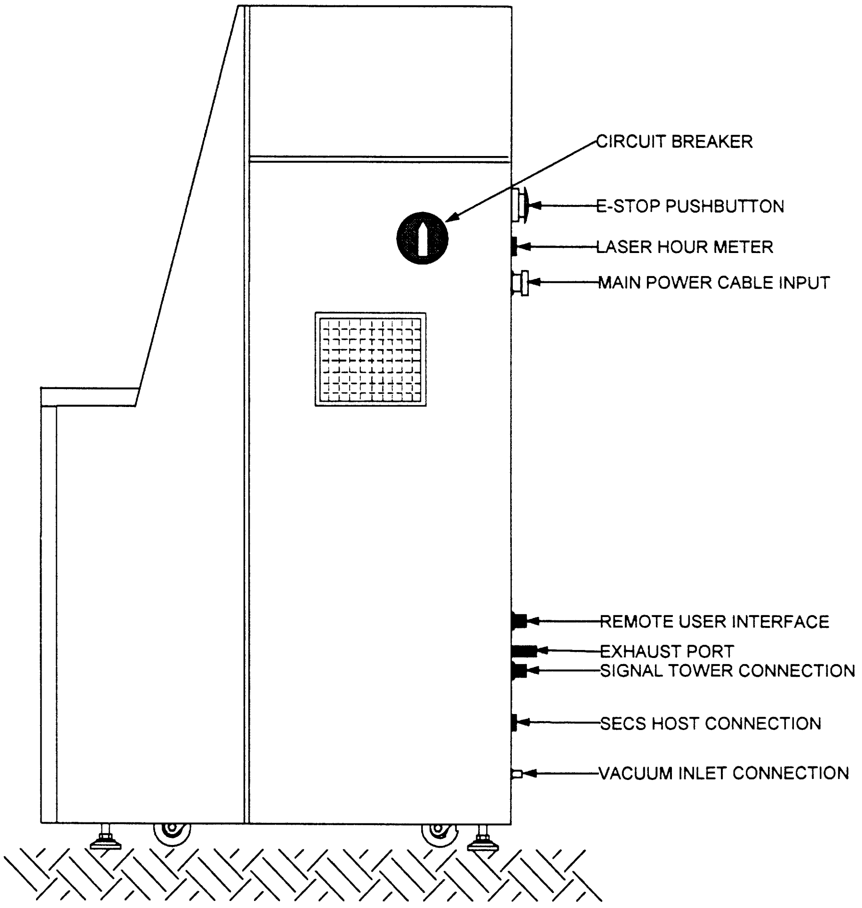

Figure 2-6. Handler/Control Cabinet — Rear Service Connections