1 AME-8100 Series Plasma Etcher System Manual
SYSTEM OVERVIEW

This chapter contains brief descriptions of the assemblies and systems of the AME-8100 Series plasma etching systems. The complete AME-8100 system, consisting of the remote components and the main reactor, is shown in Figure 1-1. Sections 1.1 and 1.2 provide introductory descriptions of mechanical assemblies and electrical and electronic systems. These systems are described in detail in Chapter 2.

1.1 MECHANICAL DESCRIPTION

The following paragraphs provide an overview of the structure of the main reactor and the remote components.

1.1.1 Main Reactor

The AME-8100 system reactor, Figure 1-2, contains:

- The process chamber
- Vacuum system components, the manifold, the turbomolecular (turbo) vacuum pump, and the cryopump and compressor (AME-8120/21 and AME-8130/31 only)
- Cold trap (AME-8130/31 only)
- Gas flow system
- The autoloader
- Manual loader (optional)
- The system controller
- The endpoint detection system
- The gas panel
- The RF matching unit
- The control panel
- Power supplies.

The process chamber, on the left side of the reactor, consists of a stainless steel bell jar, which is raised and lowered by a mechanical hoist assembly, and the RF cathode. The bell jar has two viewports, one for the operator and one for the endpoint detection system. The gas dispersion manifold is installed on the inside of the bell jar. A protective shroud, with an opening for operator access, surrounds the process chamber.

The vertical, hexagonal electrode, or hexode, is mounted on an aluminum baseplate at the left side of the reactor. When the bell jar is lowered, it seals to the baseplate and encloses the hexode to form the process chamber. During processing, RF voltage is applied to the hexode and generates the gas plasma for etching. The bell jar, which is grounded to the baseplate and the reactor frame, becomes the anode. The hexode has a rotation assembly below the baseplate to rotate the hexode for tray loading and unloading.

The process chamber baseplate has two screened openings for the vacuum system. One opening is for the turbopump and the other serves as the cryopump opening. Vacuum valves and lines are beneath the baseplate, along with the turbo vacuum pump (turbopump) of the vacuum system. The vacuum outlet from the reactor is connected to the vacuum roughing pump outside the clean room. The cryopump evacuates the process chamber at the start of the etching process. A cold trap is used to trap aluminum etch byproducts.

Also below the process chamber baseplate is the RF matching unit and the RF coupling device. The RF matching

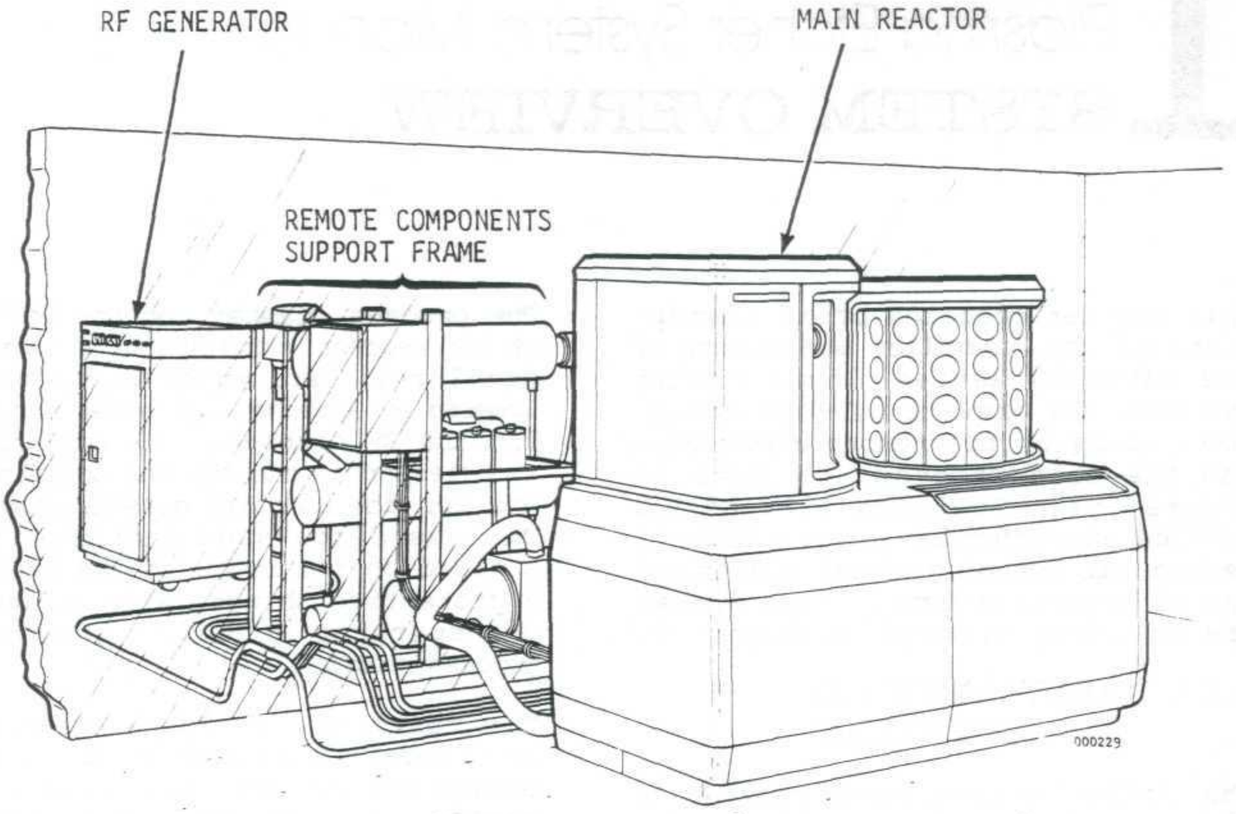

Figure 1-1. AME-8100 Series plasma etch system.

unit automatically matches the impedance of the load at the hexode to the impedance of the source at the RF generator. The RF coupling device is a pneumatic mechanical device that connects the RF to the hexode.

The endpoint detection system is mounted on the endpoint detection column at the left front corner of the reactor. One of the two viewports in the bell jar permits the collimated (parallel) laser beam to strike the wafers. The endpoint detection system also includes sensors to measure chamber pressure, hexode DC potential, and gas emissions. The emission sensors also are on the endpoint detection column.

The autoloader is on the upper right portion of the reactor. It normally holds six wafer trays but can hold up to twelve wafer trays, six loaded and six unloaded. It automatically removes unprocessed wafers from a standard wafer cassette and places them in trays for processing. The reactor operator takes these trays of unprocessed wafers from the autoloader and places them on the hexode for etching. The operator also removes trays of etched wafers from the hexode and returns them to the autoloader for unloading.

The autoloader then automatically removes processed wafers from trays and returns them to an empty cassette. Because the operator handles only the wafer trays and never touches the wafers, particle contamination of the wafers is greatly reduced.

The gas panel is at the lower right rear of the reactor. The gas panel

1.1.1 Main Reactor

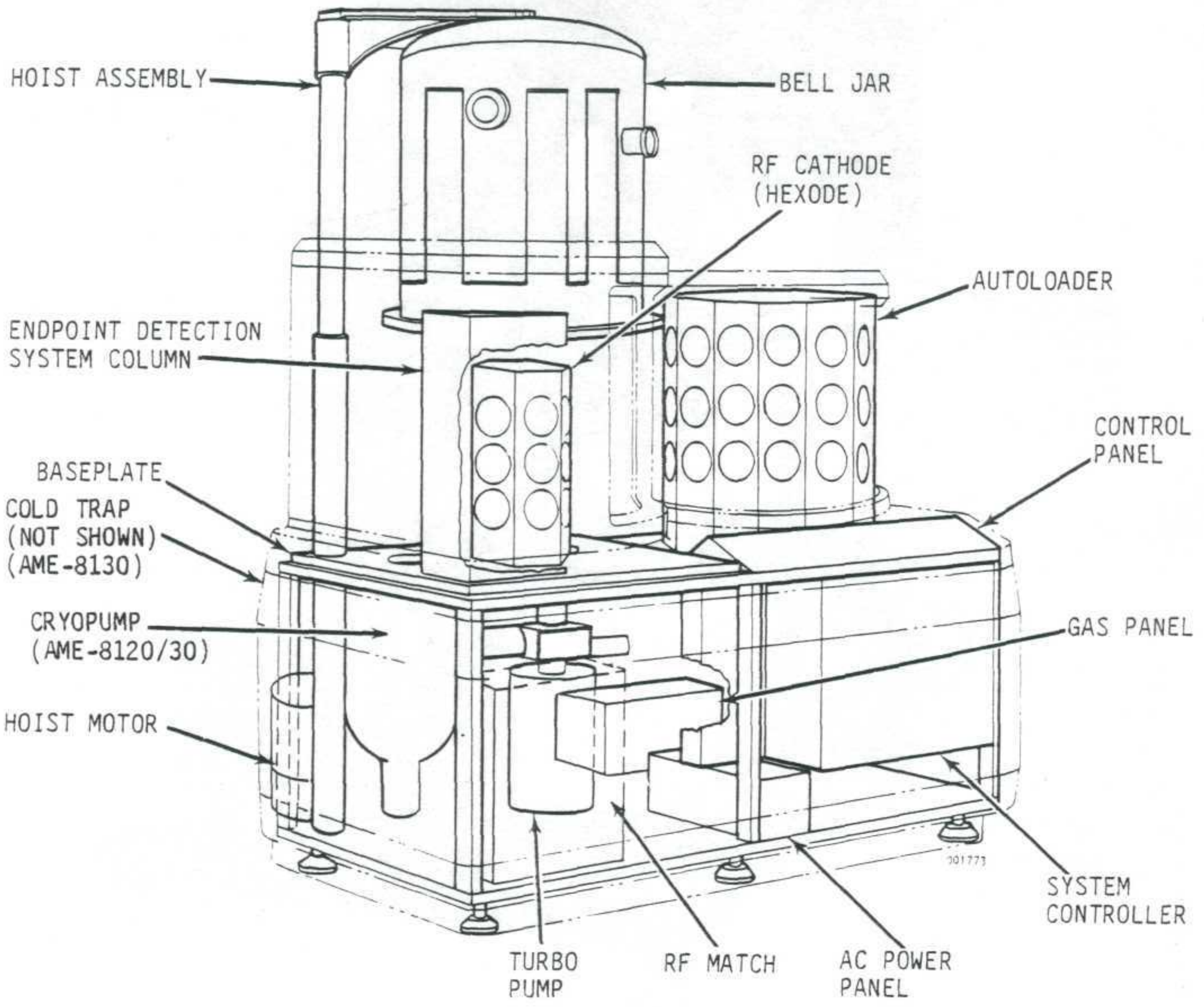

Figure 1-2. AME-8100 main reactor and its major subassemblies.

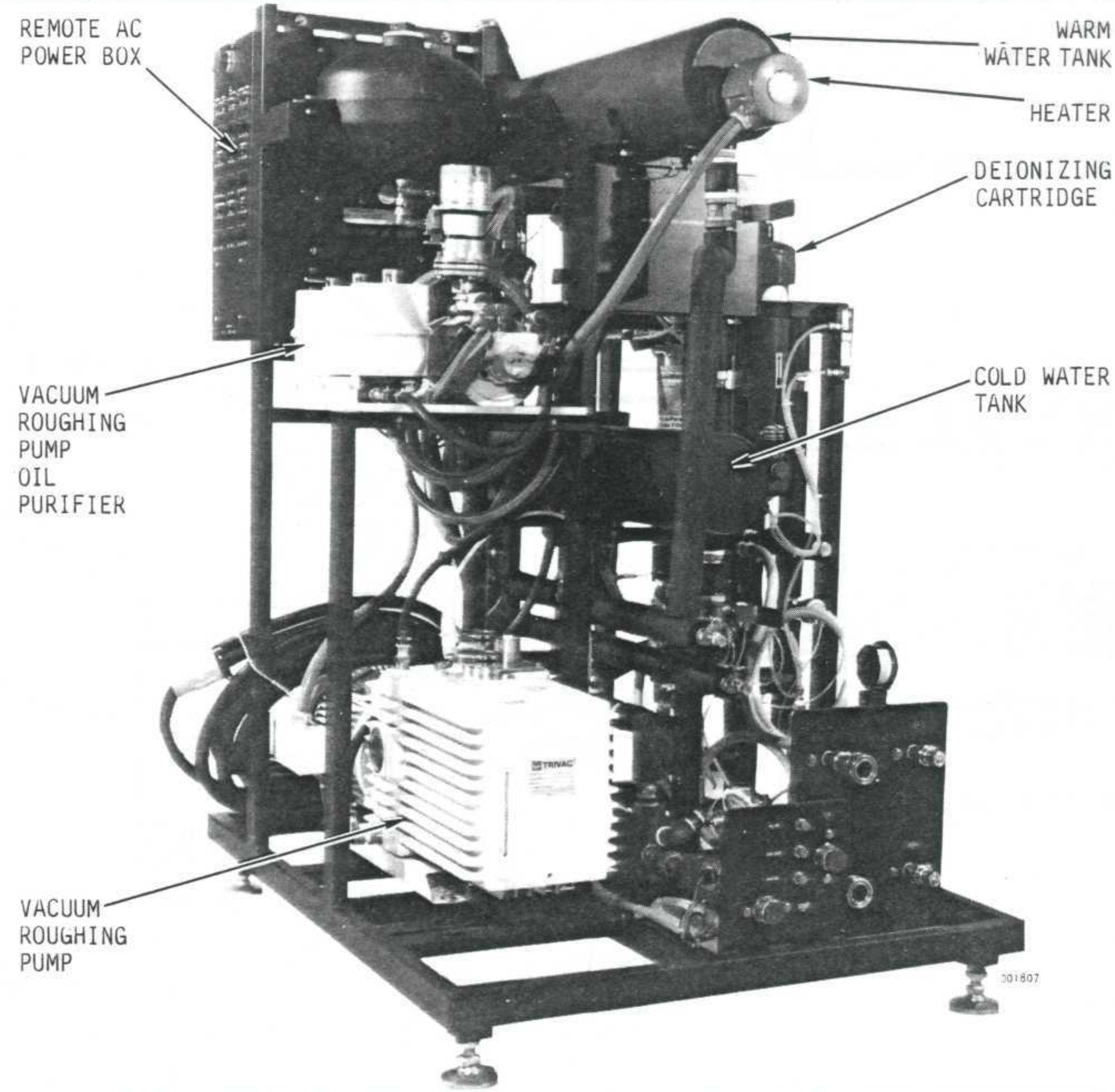

Figure 1-3 AME-8100 system remote support frame without the RF generator.

contains the gas system flow controllers and the shutoff valves. The gas panel has modules that can be removed and replaced, or individual valves and mass flow controllers can be removed and replaced if desired. The inlet connections on the gas panel are connected to the facility gas supply lines.

The system controller is contained within a chassis and card rack located behind the right front panel of the reactor. The control panel is at the top right front of the reactor cabinet.

1.1.2 Remote Components

The remote components, Figure 1-3, are outside of the clean room, normally 10 to 25 feet from the main reactor. The remote components consist of:

- The RF generator and the RF control panel
- The remote frame, which contains the vacuum roughing pump and oil purifier, the heat exchanger, the remote power box, and the air reservoir.

The RF generator is mounted in a movable cabinet. The RF control panel is mounted directly on top of the RF generator cabinet.

The vacuum roughing pump provides initial evacuation of the process chamber. It is mounted on the remote support frame and is connected to the reactor by stainless steel tubing. An exhaust line (customer supplied) must be connected from the pump to the facility exhaust system.

The heat exchanger also is mounted on the support frame. It receives chilled water from the facility water system and supplies a heated or chilled mixture of water and ethylene glycol to the reactor to control the hexode and bell jar temperatures. The heating loop consists of a reservoir with a heater, a pump, a filter, various control valves, a pressure relief valve, flow switches, and a thermal probe. The cooling loop has the same components with the exception of the heater and with the addition of the heat exchanger. The two loops are arranged in parallel with blocking valves in each loop. When heating is required, the coolant supply is blocked. When cooling is required, the heater supply is blocked.

The remote power box on the remote support frame is the connection point for facility power. Power is distributed from the box to the other remote components and to the main reactor by the umbilical lines.

1.2 ELECTRICAL DESCRIPTION

The electrical systems of the AME-8100 include the system controller, the endpoint detection system, the RF system, and the AC-DC power system.

In the system controller, analog and digital interface units send commands from the system controller to the reactor, and send data and status signals from the reactor to the system controller. The system controller holds up to five programs for process sequences. Once the programs are entered into the system controller, the operator selects the desired program and implements it with a single command at the control panel.

Self-test diagnostic routines are incorporated in the system controller to isolate malfunctions to a specific module or assembly. A two-line display on the control panel permits continuous monitoring of the process and of most parameters of the process. A strip-chart recorder can be connected to the controller to provide printouts to monitor the process and to assist in endpoint detection.

The endpoint detection system contains four groups of sensors: laser, gas emissions, chamber pressure, and hexode DC potential. Signals from these sensors are supplied as an output for monitoring the process endpoint.

The endpoint detection system consists of three channels. One channel is dedicated to the laser, and the other two to optical emission. Also there are two other channels (4 and 5) that are used for DC bias and pressure reading. Channels 4 and 5 have no circuitry in the analog interface unit. Their signal comes directly from the digital-to-analog converter (DAC) board in the system controller.

The RF system consists of the RF generator, the RF matching unit, and the RF coupling device. The RF generator is a self-contained unit that delivers up to 2000 watts of power at a frequency of 13.56 megahertz. When RF power is applied to the hexode (cathode) and the bell jar (anode) is filled with process gases under the correct pressure, the RF field between the hexode and the bell jar produces the plasma for the etching process.

Power is transmitted by a coaxial cable from the RF generator in the remote components to the RF matching unit in the main reactor. The RF matching unit automatically adjusts the impedance of the load to the RF source for maximum power transfer. Power is coupled from the RF matching unit to the hexode through a special coupling device.

The analog interface unit consists of circuit boards whose electronics transmit, receive, signal, detect endpoint and DC bias and pressure signals, control the RF generator, and measure the hexode and bell jar temperatures.

On the bottom of the analog interface unit is the frequency-to-voltage converter board, which connects to the laser components on the endpoint detection column. The three channels from the column join to three small connecters (J1, J2, and J3), on the back of the analog interface unit, that connect to the frequency-to-voltage converter board.

The two isolation amplifier boards inside the analog interface unit may appear identical but are not interchangeable. The isolation amplifier board serving the RF generator can be easily identified by its three Analog Devices model 290A isolation amplifiers; the isolation amplifier board on the other side has only two isolation amplifiers. Both of these boards serve the two temperature channels from the remote support frame into the main system. These two temperature channels are the hexode and the bell jar temperature.

The AC-DC electrical power distribution system consists of the remote power box, the main reactor power box, and the DC power box. The remote power box is the main power input for the system. The main reactor power box controls the AC power input to the system. The DC power box provides DC voltages to the electronic components and electromechanical devices.

1.3 PROCESS DESCRIPTION

The wafer etching process begins when the operator places loaded wafer trays on the hexode. The bell jar then is lowered, and the process chamber is evacuated by the vacuum roughing pump. The roughing pump lowers the chamber pressure to approximately 400 millitorr. At this point, the turbopump is activated in the AME-8110/11 oxide etch system. It continues the pumpdown to a pressure of 2×10^{-4} millitorr. Complete evacuation of the process chamber takes about 3 minutes.

In the AME-8120/21 and AME-8130/31 systems, after the rough pumpdown to approximately 400 millitorr, the cryopump is activated and the chamber is pumped down to 0.2 millitorr. At this point the cryopump is isolated and the turbopump takes over continuous chamber pumpdown.

After evacuation, the gas system admits the process gas to the chamber. The gas flows into the chamber through an inlet in the baseplate, then travels up through a feeder tube on the inside of the bell jar to a manifold block at the top of the bell jar. The gas then travels down through gas dispersion tubes placed at equal intervals around the inside of the bell jar. Gas flow rate and pressure are controlled by the throttle valve and the flow controllers. Pressures and flow rates are tailored to the specific etching process.

When gas flow and pressure are stabilized in the chamber, RF power is applied to the hexode. In AME-8110/11 systems, approximately 1.2 kilowatts of power are required for oxide etching. In AME-8120/21 systems approximately 400 to 600 watts of power are required for poly etching. For Aluminum etching a negative DC bias of approximately 200 to 300 volts is required.

The system controller adjusts the RF power either by monitoring the DC bias voltage on the hexode or by controlling the power level to a programmed constant. The gas plasma, created by the RF discharge, etches the wafers until a desired endpoint is detected.

The laser endpoint sensor monitors the etching process by directing a laser

AME-8110/8111

ETCH RATE (Å/MIN)	SELECTIVITY	UNIFORMITY			LINEWIDTH* UNIFORMITY ΔW
		WITHIN-A-WAFER	WAFER-TO-WAFER	RUN-TO-RUN	
450	15:1	±5%	±5%	±5%	<.2 micron

Material to be Etched: Thermal oxide

Underlayer: Doped or undoped polysilicon; single crystal silicon

ETCH RATE (Å/MIN)	SELECTIVITY	UNIFORMITY			LINEWIDTH* UNIFORMITY ΔW
		WITHIN-A-WAFER	WAFER-TO-WAFER	RUN-TO-RUN	
600	30:1	±7%	±7%	±5%	<.2 micron

Material to be Etched: Polymeric material (210° baked), with plasma oxide mask

Underlayer: Any semiconductor device substrate

AME-8120/8121

ETCH RATE (Å/MIN)	SELECTIVITY	UNIFORMITY			LINEWIDTH* UNIFORMITY ΔW
		WITHIN-A-WAFER	WAFER-TO-WAFER	RUN-TO-RUN	
600	15:1	±7%	±7%	±5%	<.2 micron

Material to be Etched: Undoped polysilicon; with photoresist or oxide mask

Underlayer: Thermal oxide

AME-8130/8131

ETCH RATE (Å/MIN)	SELECTIVITY	UNIFORMITY			LINEWIDTH** UNIFORMITY ΔW
		WITHIN-A-WAFER	WAFER-TO-WAFER	RUN-TO-RUN	
1000	20:1	+10%	+10%	±7%	<.5 micron

Material to be Etched: Aluminum

Underlayer: Thermal oxide

*Using positive photoresist mask such as AZ 1470 or OFPR -800, etc,; with as much as 50% overetch.

**Using positive photoresist mask such as AZ 1470 or OFPR -800, etc,; with as much as 30% overetch.

Table 1-1. AME-8100 Series standard guaranteed specifications.

beam onto a wafer surface and measuring interference signals in the reflected beam. A gas emission endpoint sensor provides a signal to the system controller when a certain gas spectrum is detected in the chamber. Chamber pressure and hexode DC potential are monitored by sensors in the vacuum system and the RF system. The hexode DC potential changes when the endpoint of the process is reached.

When an endpoint is detected, the process can be stopped. The process gas is then evacuated from the chamber, and the chamber is backfilled with nitrogen to atmospheric pressure. At this point, the operator can raise the bell jar to open the chamber and remove the wafers. However, if resist stripping is required after etching, the chamber can remain sealed, a new process can be started, and new gases can be introduced and RF power applied for the resist removal.

For general specifications for the AME-8100 systems, see Table 1-1.