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This manual is also available in other languages upon written request.

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Section 1
Safety

Introduction
Read and follow these safety instructions. Task- and equipment-specific warnings, cautions, and instructions are included in equipment documentation where appropriate.

Make sure all equipment documentation, including these instructions, is accessible to persons operating or servicing equipment.

Qualified Personnel
Equipment owners are responsible for making sure that Cambridge NanoTech Inc. equipment is installed, operated, and serviced by qualified personnel. Qualified personnel are those employees or contractors who are trained to safely perform their assigned tasks. They are familiar with all relevant safety rules and regulations and are physically capable of performing their assigned tasks.

Intended Use
Use of Cambridge NanoTech Inc. equipment in ways other than those described in the documentation supplied with the equipment may result in injury to persons or damage to property.

Some examples of unintended use of equipment include:
- using incompatible materials
- making unauthorized modifications
- removing or bypassing safety guards or interlocks
- using incompatible or damaged parts
- using unapproved auxiliary equipment
- operating equipment in excess of maximum ratings

Regulations and Approvals
Make sure all equipment is rated and approved for the environment in which it is used. Any approvals obtained for Cambridge NanoTech Inc. equipment will be voided if instructions for installation, operation, and service are not followed.

Client Modifications
Modifications to the system including, but not limited to changes to vacuum hardware, electronics, and software, void all warranty and liability.
To prevent injury follow these instructions.

- Do not operate or service equipment unless you are qualified and have fully read and understood the manual and warning labels on the system. Contact Cambridge NanoTech Inc. with any questions in case of uncertainties.

- Do not operate equipment unless safety guards, doors, or covers are intact and automatic interlocks are operating properly. Do not bypass or disarm any safety devices.

- Before adjusting or servicing equipment, or touching any of the parts, turn off the heaters in the software, wait until all temperature sensors are at room temperature, then shut off the power supply and unplug the main power and wait until all unmonitored parts have cooled down. Lock out power and secure the equipment.

- Relieve (bleed off) pneumatic pressure before adjusting or servicing pressurized systems or components, such as gas cylinders. Never disconnect high pressure gas cylinders without specific knowledge. Refer to your supplier for instructions.

- Obtain and read Material Safety Data Sheets (MSDS) for all materials used. Follow the manufacturer’s instructions for safe handling and use of materials, and use recommended personal protection devices.

- To prevent injury, be aware of less-obvious dangers in the workplace that often can not be completely eliminated, such as hot surfaces, sharp edges, energized electrical circuits, and moving parts that can not be enclosed or otherwise guarded for practical reasons.
Fire Safety

To avoid a fire or explosion, follow these instructions.

• Do not place flammable materials underneath, on or near the unit. Do not place paperwork, clothing etc. on or near the unit.

• Do not run the system unattended; do not run the system overnight.

• Do not heat materials to temperatures above those recommended by the manufacturer. Make sure heat monitoring and limiting devices are working properly. Note the maximum temperature settings for different parts. Solenoid valves are rated to 115 °C and should not be heated above that temperature. Center heater maximum temperature is 400 °C, while outer heater should not be set higher then 250 °C because of the Kalrez™ O-ring. The tee and flexible bellows of the pumping line should not be heated above 180 °C. Temperature of the precursors should not exceed safety or decomposition temperature of the chemical used. Maximum for the precursor heater jacket is 180 °C.

• The pump may exhaust small amounts of unreacted precursor. Since Cambridge NanoTech Inc. does not supply the chemicals, responsibility for safe venting and exhausting lies with the customer. General exhaust recommendations include using inert pumping fluid such as Fomblin SV, fireproof metallic exhaust lines to prevent fire. Refer to local codes or your material MSDS for guidance. Minimize precursor use. Do not add vapor traps in the pumping line, upon exposure to air large amounts of trapped precursor may ignite or cause chemical burns.

• Know where emergency stop buttons, shutoff valves, and fire extinguishers are located.

• Clean, maintain, test, and repair equipment according to the instructions in your equipment documentation.

• Use only replacement parts that are designed for use with original equipment. Contact your Cambridge NanoTech Inc. representative for parts information and advice.
**Electrical Safety**

To avoid electric shocks, follow these instructions.

- At the time of installation the stainless steel system cabinet must be grounded by attaching the supplied ground wire to the facilities grounding loop.

- Turn off and unplug the electronic control unit prior to connecting or disconnecting any sensor, heater, valve or other components.

- Do not disconnect live electrical circuits while working with flammable materials. Shut off main power first to prevent sparking.

**Chemical Safety**

To avoid chemical hazards, follow these instructions.

- Know the nature of the precursors you are working with (read MSDS).

  Some precursors such as trimethylaluminum are pyrophoric, they burn upon exposure to air. Precursors should never be disconnected from the manual valve they were supplied with. Make sure that manual valve is closed before removing the precursor-valve combination from the system.

  Pump/purge the space between solenoid valve and manual valve before disconnecting any precursor. Always wear proper protection equipment when removing precursors. Precursor replacement should only be conducted by qualified personnel. Read the section on precursor removal before proceeding. Cambridge NanoTech Inc. can be reached for safety assistance with precursor replacement/removal procedure, although the final responsibility lies with the user.

**Action in the Event of a Malfunction**

If a system or any equipment in a system malfunctions, shut off the system immediately and perform the following steps:

- Disconnect and lock out system electrical power. Close valves and relieve pressures.

- Identify the reason of the malfunction and correct it before restarting the system.

**Disposal**

Dispose of equipment and materials used in operation and servicing according to local codes.
Section 2
Theory

Atomic Layer Deposition: Principle of Al₂O₃ formation

Atomic Layer Deposition (ALD) is a technique that allows growth of thin films, atomic layer by layer. Deposition of Al₂O₃ from water and trimethylaluminum (TMA) precursors will be used to illustrate the principle of ALD. Recipes for other materials can be found in the literature. The chemical principle of Al₂O₃ growth from water and TMA is outlined in Figure 1. Five steps can be identified:

1. Put in a sample which is hydroxylated from exposure to air, oxygen or ozone (Figure 1A).
2. Pulse the TMA precursor; TMA will react with the OH groups on the surface. TMA does not react with itself and the monolayer formed passivates the surface (Figure 1B, 1C).
3. Remove unreacted TMA molecules by evacuation and/or purging with nitrogen (Figure 1D).
4. Pulse water (H₂O) into the reactor. This will remove the CH₃ groups, create Al-O-Al bridges, and passivate surface with Al-OH. CH₄ (methane) is formed as a gaseous byproduct (Figure 1E, 1F).
5. Remove unreacted H₂O and CH₄ molecules by evacuation and/or purging with nitrogen (Figure 1G).

Steps (a)-(g) form a cycle. Each cycle produces a maximum of 1.1 Å of Al₂O₃ depending on temperature. Thus, 100 cycles produces 11 nm of Al₂O₃.

Modes of Operation

There are two main modes of operation:

1. Continuously flowing nitrogen carrier gas while pulsing (adding) precursor and pumping continuously
2. Pulsing precursors with stop valve closed and pumping in-between pulses

This research system can operate in either mode.

Pyrophoric Precursors

Trimethylaluminum (TMA) is a liquid at room temperature and is pyrophoric. This means that it burns upon exposure to air. TMA reacts with water vapor in the air. For this reason, the TMA bottle may only be opened in a glove box with inert atmosphere by experienced professionals such as at the chemical supply companies (Strem, Sigma-Aldrich etc).
Fig. 1. Chemical reactants in the ALD process are introduced into the deposition chamber as gases, and supplied in pulses delivered to the reactor at different times. Reactants are separated from one another in the flow stream by a purge gas or evacuation. Each reactant pulse chemically reacts with the wafer surface, making ALD a self-limiting process capable of precise monolayer growth.
Section 3
Installation

Introduction

The Savannah 100 ALD system can be easily disassembled and assembled for maintenance. Installation must be performed by qualified personnel observing all safety regulations and procedures. Helium leak checking of the entire assembled system is advised upon receipt of the system and upon reassembly. Viton NW fitting O-rings should always be replaced with new ones. The reactor Kalrez O-ring can be used for extended time.

System Assembly

Unpack and identify all parts before the assembly. Start with installing the cabinet at the place of intended use. Make sure that enough space is provided for rear and side access to the system.

Reactor Assembly

Tubular (Outer) Heater:

Take the tubular (outer) heater and place it into the skirt of the bottom of reactor aligning the bent areas of the heater in the center between the hinges. Test that the heater is properly aligned by sliding the heaters electrical connections and bent ends through the top elliptical hole in the center of the top of the cabinet. The tubular heater should pass through the center of the hole and should not be touching the sides of the hole. Make sure that the 4 bolts align as well. Once the alignment has been confirmed take 4 washers and slide one over each shoulder bolt and tighten them with 3/4” length 1/4” wide hex nuts.
**Inner Disk Heater:**

Take the inner disk heater and place it around the center threading, making sure that the electrical connections are aligned in the center towards the handle, away from the hinges. Tighten the heater down with a 3/8” 5/16” nut using a 5/8” wrench to insure good thermal contact.

Thread the outer heater electrical connections through the larger center elliptical hole in the top rear of the cabinet. Through the smaller elliptical hole towards the center is where the electrical connection for the inner disk heater is threaded. Make a loop in the center heater wire to avoid a direct bend at the spade lugs and to provide strain relief.

**RTD’s:**

Before securing the reactor to the cabinet with 4 nuts, take two RTD’s and slip the bottom of the compression fitting plus the ferrule over it. Insert the outer (wall) RTD into a compression fitting welded on the inside part of the top of the cabinet and push it all the way into the hole in the reactor. Be careful not to lift the reactor, but to insure that the tip of the RTD is all the way inside. Start with the RTD closer to the front of the cabinet that goes into the hole on the side of reactor. Repeat this procedure to connect the center RTD, hand tightening the compression fitting nuts (over tightening can break the RTD).

Secure the reactor to the cabinet with 4 nuts and tighten the compression fittings.

Note: Once the RTD’s are in place they do not have to be removed in order to take the reactor off for cleaning or to install it back after the procedure: the reactor can slide over.

**Inside of the cabinet with reactor and RTD’s installed.**
O-ring:

Insert the O-ring into the reactor O-ring groove. Should one need to take out the O-ring, brass O-ring removal tools are provided to pick out the O-ring in the pick out moon. Make sure never to scratch the stainless steel reactor surface or the aluminum lid surface.

Lid:

The aluminum lid is placed onto the reactor and hinged on the back.
Pumping Line Assembly

All connections of the pumping line are made with Kwik Flange™ (KF) clamps (also called QF or NW by other manufacturers). Make sure that a properly sized (KF16), clean Viton™ O-ring with a centering ring is used and clamps are securely tightened by hand.

The pumping line assembly is attached to the KF exit port of the reactor at the end of the procedure.

Stainless steel clamp with red wing nut.

Place the stainless steel tee into one of the two heater halves so that two threaded screw holes are facing up; one on the top right and one on the bottom left. On the back of this heater half the heater cartridge is inserted into the top right side hole. Make sure that the heater cartridge sits in the center of this heater half. This is to ensure that the wire coming out from the heater cartridge is flat against the heater half. Wires are held together with the strain relief.

An RTD is screwed into the treads hole at the top. The top half of the heater block is attached and tightened with an Allen key.

The pressure gauge is attached to the right side of the cross with the RJ45 connection facing down. The nut of the clamp should be facing down. The stainless steel tube body of the gauge can be removed for cleaning or replacement. Cleaning of the body should be done very gently as to not break the filament. The gauge comes calibrated, but should calibration at atmosphere and/or vacuum be necessary, please refer to the instruction manual that is included in the Appendix.

The stop valve is attached to the left of the tee. The red wing nut of the clamp should be facing down. The stop valve is attached in such a manner that the electrical connection and the other KF16 port on the stop valve point in the same direction - down. The stop valve can be disassembled for cleaning. The instruction manual is included in the Appendix.
The flexible bellows hose is attached to the stop valve with a matched KF connection. The red wing nut of the clamp should be facing right.

Make sure that the reflector plates fit around the tee with the stop valve and pressure gauge in place.

Lift the entire assembly (tee, gauge, stop valve, and hose) and attach the top KF16 connection of the tee to the KF16 exit port of the reactor using a red wing nut clamp and a centering ring. Have the red nut on the right hand side pointing towards the back of the gauge and out of the cabinet door in order for the reflector plates to fit properly around the assembly. The pressure gauge should be facing toward the cabinet door with the stop valve pointing towards the back of the cabinet.

Attach the bellows to the inlet of the pump. The bellows may need to be stretched a little in order to do so.

The large flexible hose heater is wrapped around the bellows.

Once all of these attachments have been made, the pump can be plugged in, and the heat reflecting plates can be installed around the tee. The reflector plates fit around the tee and the attachments and come together with magnets. Please refer to the pictures.

Note: Always treat the KF connection flange faces with care and cover them with plastic caps if not in use, scratching can cause leaks.

Pumping line assembly with the heat reflecting plates connected to the KF port of the reactor.
Precursor Assembly

Precursor assembly parts are connected by metal face seal VCR™ fittings. A new metal gasket should be used every time a connection is made. Extra care should be taken in order to keep VCR connecting surfaces from scratches. Once disconnected, use plastic covers and plugs to protect polished VCR face surfaces.

Do not over tighten VCR fittings. Once connected, first hand tighten and then tighten by a 45°.

Two port precursor manifold.

Take the two port precursor manifold and with a new ½" gasket and attach it to the female ½" nut of the reactor. Hand tighten. Follow the same instructions for the larger precursor manifolds. When you are ready to tighten the fitting use a 1 1/16" and 15/16" wrench. The 1 1/16" wrench holds the ½" female fitting above the cabinet, while the 15/16" wrench tightens the nut inside the cabinet.

Take two high speed solenoid valves and attach the two halves of the male VCR split nuts around the naked glands. Using a new gasket for every VCR-VCR connection attach each valve to the precursor manifold. See picture on the next page for orientation. Again hand tighten. Attach an RTD to one of the valves.

Note: The high speed solenoid valves are rated to up to 115 °C.
Two port nitrogen manifold.

Take the nitrogen manifold and insert it into the back of the solenoid valves. Hand tighten. Attach the other end of the nitrogen manifold to the MFC.

Precursor manifold with high speed solenoid valves and nitrogen manifold attached.

Filling of the Precursor Cylinder

The precursor cylinder should be only filled maximum half way to ensure plenty of vapor space for eg. 20 ml of trimethylaluminum.

Once the manual valve is attached to the solenoid valve the space that is formed between these two valves is called the headspace and has to be evacuated prior to the opening of the manual valve.

Note: The arrow on the manual valve attached to the precursor should be pointed toward the cylinder with the chemical.

Never disconnect manual valve from the precursor container, only authorized manufactures can replenish and clean precursor cylinders. Always disconnect cylinder-valve assembly with manual valve closed.

Attach the male VCR fitting on the manual valve on top of the precursor cylinder to the high speed three way valve female nut using a gasket.

The water precursor does not require a manual valve and the solenoid valve can be connected directly to the male VCR fitting of the cylinder.

Note: The nitrogen port of the valve is always open and the valve only operates on the precursor inlet.
Some precursors require a snap on heating jacket.
Note: TMA does not need to be heated.

Heater Block for Valves:

Heater block for solenoid valves consists of two halves, left and right.

Place the heater block with its reflector plates around the precursor manifold (top of the valves) and tighten the two halves together using an Allen key, once the entire precursor unit is attached to the reactor. It is convenient if the heater block screw faces the left side of the cabinet.

The heater block is fitted around the two port VCR manifold. Shown is an assembly with two 3-port valves. The nitrogen line manifold is inserted into the back of the valves and goes to the mass flow controller.

**Carrier Gas Connection**

Carrier gas (nitrogen, argon or other inert gas) is supplied through the provided mass flow controller (MFC). The supplied MFC is calibrated for nitrogen and a gas correction factor has to be used for other carrier gases. The MFC ¼” male VCR inlet pressure should be around 20 psi (pressure regulator is not provided). The MFC ¼” male VCR outlet is connected to the inert gas input of the 3-port solenoid valve on the precursor(s) via a stainless steel nitrogen manifold with VCR connections.
Electrical Connections

Plug all the connections into their appropriate locations on the electronic control unit, which is attached to the inside left wall of the cabinet.

Twenty-two 3-pin connectors in positions 0 through 21 are for 115V AC. Sixteen 2-pin connectors in position 6-21 are for RTDs, and positions 0-5 (2-pin connectors) are for 24V DC valves.

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<td>• • •</td>
<td>Stop Valve</td>
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<td>Solenoid Pulse Valve 0 – Plug in the valve (precursor) that you want to pulse first.</td>
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<td>Solenoid Pulse Valve 1</td>
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### Heater and RTD section:

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<td>21</td>
<td>System Cabinet Cooling Fans</td>
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</table>
READ ALL INSTRUCTIONS IN THEIR ENTIRETY BEFORE OPERATION

Section 4  Operation

Software Installation

Software for the Savannah 100 ALD system can be installed from the supplied CD. See instruction.txt.

Preparation

Make sure that the system is fully assembled and all electrical connections to the control unit are properly made. The control computer is connected to the electronic control unit via a USB cable.

The system should be degassed and leak checked (refer to the appropriate section of the manual) prior to use.

Turn on the electronic control unit and the vacuum pump.

Start the software by double clicking the “Savannah 100” program icon. If running the LabView version of the software press the run button (white arrow) in the top left corner. The arrow turns black once the program is running.

Do not run the program with the USB cable disconnected.

Control Software Features

This subsection describes the main features of Savannah 100 control software.

The control program allows the operator to control the solenoid valves, pumping system, heaters, and to set deposition recipes.

Buttons:

Program  –  stops the program
Stop Valve  –  operates the stop valve to evacuate the reactor
All Heaters  –  turns all the heaters ON/OFF

Note: Make sure that there is no run in progress before stopping the program. Abort run first if necessary, then press Stop. Do not close the window of the program while it is running.
Run Cycle Area:

Cycle Matrix — allows programming of a cycle sequence (recipe). The number of steps can be changed by toggling the upper left arrows (arrows are disabled during run). The active step is indicated in blue. The valve number is 0-5, depending on which valves have been connected. Valve 0 pulses first. Then valve 1 and so forth. The pulse duration can be set between 0.0001 and 1.31 sec, however, the valves only start pulsing for t>0.007 sec. Expo indicates the exposure time. If Expo>0, the stop valve will close before the precursor valve pulses, and the stop valve opens again Expo seconds after the pulse valve has closed. With Expo=0, the stop valve will remain open. The pumping time Pump (s) controls the pumping time between the pulses.

Cycles — programmed number of cycles with current cycle number displayed underneath.

Flow — sets inert gas (i.e. nitrogen) flow through the mass flow controller (MFC) with actual measured flow indicator underneath. Flow can be changed during a run. Setting the flow to 10-20 sccm is usually sufficient for most processes. Make sure that the carrier gas is always ON to prevent precursor(s) from backdiffusing into the nitrogen lines.

Delay - time delay before the start of the run (this is used to degas the sample or system or for temperature stabilization).

Runtime — time elapsed from the beginning of current run.

Save Run — check this box to save the run data into a file.

Start/Abort Run — starts or aborts current run.
**Reactor Pressure Plot Area:**

This plot tracks the reactor pressure read by the pressure gauge installed in the pumping line assembly. Pulses of the precursors are clearly seen on the plot. Time scale can be reset by pressing **Reset Time** button.

**Heaters Control Area:**

This section of the program window controls the temperature of the heaters. Temperature can be set by typing in values into the light blue areas. The current temperature reading is indicated in the red area of each heater (under the set point area).

**Precursor safety warning:**

Before removing precursor line:

1. Read all safety precautions in the user manual.
2. Read MSDS of precursor.
4. Pulse the precursor pulse valve at least 100 times 1 second to remove residual vapor in the space between manual and pulse valve (headsace).
6. Call technical support when unsure.

**Help Button:**

Help button activates context help. Hover over a control to read detailed description.
**Venting the System**

The system is vented by closing the **Stop Valve** (reactor is isolated from the pump) and filling the reactor with carrier gas. For faster venting a higher flow can be set via the MFC (100 sccm).

**Degassing the System**

Before using the system for the first time after the installation or when new connections or precursors have been added or replaced, the system has to be degassed and checked for leaks.

Power up the system and evacuate the reactor (**Stop Valve** is opened). Set the solenoid valve heater to 80 °C, tee and bellows heaters to 150 °C, and the inner and outer reactor heaters to 200 °C and 200 °C respectively. Wait until the temperature reaches the set point for each heater. Note the base pressure of the system.

Degas the water cylinder by doing a run with about 3-5 cycles, “Valve 0” **Pulse** time of 1.3 seconds, and the **Pump** time set around 3 seconds. Recommended setting for **Flow** is 0-5 sccm.

After the water source degassing run is done and the temperatures have stabilized note the base pressure of the system.

Degas the headspace between the solenoid and manual valve of the second precursor by doing the following. Keeping the manual valve on the precursor (trimethylaluminum (TMA) in this example) still closed do a run with valve 1 opening for a 1.3 seconds **Pulse** time. The **Pump** time is again around 3 seconds and the **Flow** is 5 sccm.
Loading/Unloading the Sample

Performing a Growth Run

When the base pressure during this run is the same as the base pressure of the system then this area has been degassed.

*Note:* Degas the headspace of atmospheric gases before opening the manual valve every time the space between manual and solenoid valves has been exposed to air. Also degas this area after closing the manual valve if the solenoid valve is to be removed.

To load/unload the sample vent the reactor (refer to Venting section of the manual). Once the reactor is at atmospheric pressure, open the lid and place the sample into the recessed area in the center of the reactor. Close the lid and evacuate the system.

ALD growth of Al₂O₃ is used to demonstrate a deposition procedure.

After system has been degassed and vented:

⇒ Load the sample
⇒ Pump down the reactor
⇒ Make sure that the Cycle Matrix has two rows available: one for the water valve and one for the TMA valve
⇒ For valves 0 and 1 set Pulse time to 0.07 sec, Expo time – 0 sec, Pump time – 4 sec
⇒ Set number of Cycles to 300, carrier gas Flow to 20 sccm
⇒ Delay time can be set to 10-30 min to provide enough time for pre-run purge and temperature stabilization.
⇒ Check Save Run box to save run data.
⇒ Press Start Run button.
In this example about 33 nm of aluminum oxide is deposited. This thickness is almost invisible to the eye, but if the wafer is turned over an “ALD frame” can be seen on the backside of the wafer.

**Use of Expo**

Exposure mode can be used for the coating of ultra high aspect ratio structures. In the following screen shot Pulse time for both valves is set to 0.2 seconds. Expo time is set to 4 seconds. During this time (exposure) the stop valve is closed to allow the current precursor to fully react with the surface of the sample. Pump time is set to 10 seconds to provide sufficient time for removal of any unreacted precursor and reaction byproducts.

It is recommended to use carrier gas for the process of this type. In this example, 5 sccm was used.

This example is only used to illustrate the principle of using the stop valve during a run.
If more dose of a single precursor is needed, multidosing can be used instead of or in addition to using Expo. The following screenshot of multidosing illustrates that each valve can be pulsed multiple times for varying amounts of time and each valve can have different pumping times. In this example valve 0 is first pulsed for 0.01 s, with a pump (purge) time of 5 seconds, after which it is pulsed again for 0.5 seconds. After the second pulse the pump time is 15 seconds. Then valve 1, pulses for 0.1 seconds after which 10 seconds of pump time is used before the cycle repeats.
Section 5
Technical specifications

Technical Information

Electrical Specifications

Electrical Supply .......................................................... 110V, 10A
Main supply voltage fluctuation not to exceed ±10% of the nominal
supply voltage.
Fuses ................................................................. ¼”x1¼” fast acting 250V/10A

Facilities Recommendations

It is recommended to use a corrosion resistant (filled with PTFE
oil, e.g. Fomblin™, preferably SV oil) rotary vane pump with a
recommended pumping speed of 3.5 cfm.

Use of an uninterruptible power supply for the control computer is
strongly recommended. Alternatively one can use a notebook
computer with a good battery as a back up power.

A supply of high purity nitrogen through stainless steel tubing with
a ¼” VCR female end connection and minimum pressure of 20 psi
(see Mass Flow Controller specifications for maximum pressure
ratings) is required.

It is recommended to use a PC compatible computer with a fresh
installation of Windows 2000 or XP Operating System and an
available USB port.

Environmental Specifications

Operating Temperature .................................15-40 °C (60-100 °F)
Humidity .................................. Max 80% at 30 °C (50% at 40 °C)
Storage Humidity ........... 0-95% relative humidity, non-condensing
Indoor use only.
Pollution degree .......................................................... 2
Installation category .................................................. II
Operation Altitude ................................................. Max 2000m

Note: This equipment has been tested and found to comply with
the limits for a Class A digital device, pursuant to part 15 of the
FCC Rules. These limits are designed to provide reasonable
protection against harmful interference when the equipment is
operated in a commercial environment. This equipment generates,
uses, and can radiate radio frequency energy and, if not installed
and used in accordance with the instruction manual, may cause
harmful interference to radio communications. Operation of this
equipment in a residential area is likely to cause harmful
interference in which case the user will be required to correct the
interference at user’s own expense.
Section 6
Appendix

OEM manuals for stop valve, pressure gauge, mass flow controller, and optional equipment.