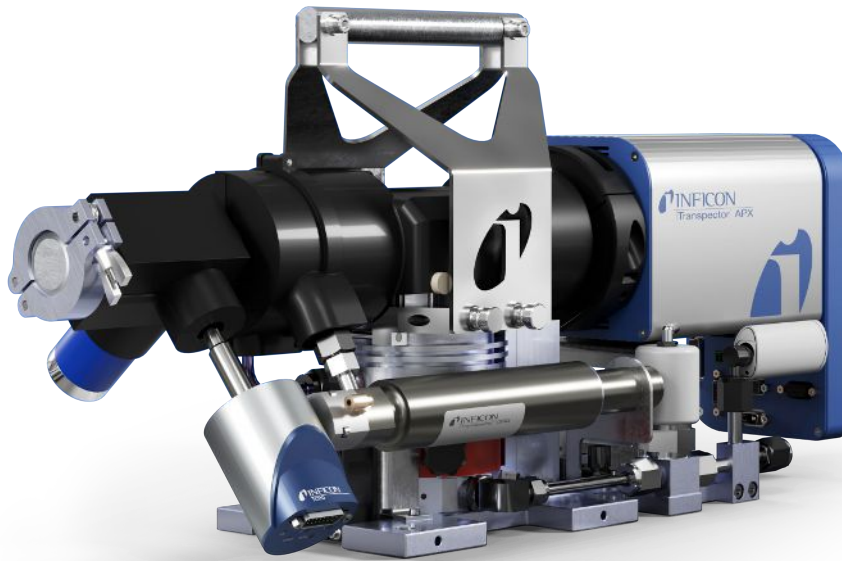




Operating Manual

# Transpector<sup>®</sup> APX ALD

Residual Gas Analyzer



INFICON

Two Technology Place

East Syracuse, NY 13057-9714

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## 2 Revision History

### 2.1 Revision History Chart

| Date | Rev. Level | Description         | Approval Service Engineer |
|------|------------|---------------------|---------------------------|
|      | 1          | Transpector APX ALD | Killian Hart              |
|      |            |                     |                           |
|      |            |                     |                           |
|      |            |                     |                           |

## 3 Bibliography

For further information on partial pressure analyzers, see Partial Pressure Analyzers and Analysis, M. J. Drinkwine and D. Lichtman, American Vacuum Society Monograph Series, or A User's Guide to Vacuum Technology, J. F. O'Hanlon, John Wiley and Sons (1989). The latter book also contains a wealth of information on related topics including gas flow, pressure gauges, pumps, materials, and the design of vacuum systems.

## 4 Warranty

**WARRANTY AND LIABILITY - LIMITATION:** Seller warrants the products manufactured by it, or by an affiliated company and sold by it, and described on the reverse hereof, to be, for the period of warranty coverage specified below, free from defects of materials or workmanship under normal proper use and service. The period of warranty coverage is specified for the respective products in the respective Seller instruction manuals for those products but shall not be less than one (1) year from the date of shipment thereof by Seller. Seller's liability under this warranty is limited to such of the above products or parts thereof as are returned, transportation prepaid, to Seller's plant, not later than thirty (30) days after the expiration of the period of warranty coverage in respect thereof and are found by Seller's examination to have failed to function properly because of defective workmanship or materials and not because of improper installation or misuse and is limited to, at Seller's election, either (a) repairing and returning the product or part thereof, or (b) furnishing a replacement product or part thereof, transportation prepaid by Seller in either case. In the event Buyer discovers or learns that a product does not conform to warranty, Buyer shall immediately notify Seller in writing of such non-conformity, specifying in reasonable detail the nature of such non-conformity. If Seller is not provided with such written notification, Seller shall not be liable for any further damages which could have been avoided if Seller had been provided with immediate written notification.

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**These instructions do not account for every contingency that may arise in connection with the installation, operation or maintenance of this equipment. Should you require further assistance, please contact INFICON.**

---

## 5 Declaration of Conformity



### DECLARATION OF CONFORMITY

This declaration is issued under the sole responsibility of the manufacturer INFICON. The object of the declaration is to certify that this equipment, designed and manufactured by:

**INFICON Inc.**  
Two Technology Place  
East Syracuse, NY 13057  
USA

is in conformity with the relevant Community harmonization legislation. It has been constructed in accordance with good engineering practice in safety matters in force in the Community and does not endanger the safety of persons, domestic animals or property when properly installed and maintained and used in applications for which it was made.

**Equipment Description:** INFICON Transpector APXA, APXH, CPXH, SPXP Residual Gas Analyzer

|                               |                    |                                                                                 |
|-------------------------------|--------------------|---------------------------------------------------------------------------------|
| <b>Applicable Directives:</b> | 2014/35/EU (LVD)   | Electrical Equipment (Safety) Regulations 2016 (UK)                             |
|                               | 2014/30/EU (EMC)   | Electromagnetic Compatibility Regulations 2016 (UK)                             |
|                               | 2015/863/EU (RoHS) | Substances in Electrical and Electronic Equipment Regulations 2012 (AS AMENDED) |

**Applicable Standards:**

|                   |                                                                                                                                                                                                                                                                                                                    |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Safety:</b>    | IEC 61010-1:2010/AMD1:2016 3 <sup>rd</sup> Edition: Listing # E115486                                                                                                                                                                                                                                              |
| <b>Emissions:</b> | EN 61326-1:2020 (Radiated & Conducted Emissions)<br>(EMC – Measurement, Control & Laboratory Equipment)<br><br>CISPR 11:2015/AMD2:2019<br>EN 55011:2016/A11:2020 Emission Standard for Industrial, Scientific and Medical (ISM) radio RF equipment<br>FCC Title 47 CFR Part 18 Class A emission requirements (USA) |
| <b>Immunity:</b>  | EN 61326:2020 (Industrial EMC Environments)<br>(EMC – Measurement, Control & Laboratory Equipment)<br>Immunity per Table 2                                                                                                                                                                                         |
| <b>SEMI:</b>      | SEMI S2-0821 Compliant                                                                                                                                                                                                                                                                                             |

**CE and UKCA Implementation Date:** October 18, 2022

**Authorized Representatives:**

Digitally signed by Andrew Klammm  
Klammm  
Date: 2022.11.03 18:57:30  
-04'00'

Andrew Klammm  
Quality Manager, ISS

Digitally signed by Samuel Carroll  
Carroll  
Date: 2022.10.24 14:34:01  
-04'00'

Samuel Carroll  
Vice President of Engineering

ANY QUESTIONS RELATIVE TO THIS DECLARATION OR TO THE SAFETY OF INFICON'S PRODUCTS SHOULD BE DIRECTED, IN WRITING, TO THE AUTHORIZED REPRESENTATIVE AT THE ABOVE ADDRESS.

## 6 Safety

### 6.1 Definition of Cautions and Warnings

When using this manual, please pay attention to the notes, cautions and warnings found throughout. For the purposes of this manual they are defined as follows:



#### **CAUTION**

This is a Caution paragraph. It cautions against actions which may cause an instrument malfunction or the loss of data.



#### **WARNING**

This is a General Warning paragraph. It warns against actions which may cause bodily injury.



#### **WARNING**

This is an example of a Electrical Warning paragraph. It warns of the presence of electrical voltages which may cause bodily injury.

### 6.2 Personal Qualifications

All work described in this document may only be carried out by persons who have suitable technical training and the necessary experience.

### 6.3 General Safety Instructions



#### **CAUTION**

The product is not for use in a manner not specified by the manufacturer. If the product is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.



#### **CAUTION**

Only trained personnel may perform service actions on the product.

## 7 Getting Started

### 7.1 Using This Manual

Please read this Operating Manual before operating the instrument.

### 7.2 Purpose of Transpector APX ALD

Inspector APX ALD samples a representative fraction of a process environment and directs the gas sample to a Residual Gas Analyzer (RGA). Inspector APX ALD can detect levels of impurities in process gases at sub-ppm levels.

Inspector APX ALD utilizes ALD coated parts and a harsh application closed ion source to extend the lifetime of the instrument in harsh applications with minimal downtime.

### 7.3 Description of Inspector APX ALD

Inspector APX ALD is comprised of:

- **FabGuard® Software:** FabGuard software provides automatic or manual control and status information. It includes a full array of basic RGA features, including Spectrum or Selected Peaks scanning, Leak Detection and Recipe Generation.
- **Quadrupole Sensor:** the quadrupole sensor analyzes gases by: (1) ionizing the gas molecules, (2) separating the ions by their mass-to-charge ratio, and (3) measuring the quantity of ions at each mass. This determines gases that are present within a vacuum chamber or other vessel, and it is used to investigate the nature of a process or to monitor process conditions.
- **Electronics Module:** the electronics module controls the sensor, pumping system, valves, heaters, and power to all elements of the system. The electronics module and quadrupole sensor are a matched set. The electronics module mounts on the sensor.
- **Pumping System:** the pumping system provides process sampling from 1.2 atmospheres to high vacuum. A priani gauge installed on the foreline protects the turbo pump from excess strain from insufficient backing pressures. An optional foreline roughing pump with remote control integration is available.
- **Inlet Valves and Single Pressure Inlet:** the inlet valves and single pressure inlet provide sampling at specific pressure ranges, a calibration reference, and a process pressure gauge.

## 7.4 Transpector APX ALD - Single Pressure Data Sheet

### 7.4.1 Specifications

|                                                    |                                                     |                                       |                                       |
|----------------------------------------------------|-----------------------------------------------------|---------------------------------------|---------------------------------------|
| Mass range                                         | 1 to 100 amu                                        | 1 to 200 amu                          | 1 to 300 amu                          |
| Peak width at 10% peak maximum                     | 0.9 amu $\pm$ 0.05 amu                              |                                       |                                       |
| Ion source type                                    | Closed ion source                                   |                                       |                                       |
| Total pressure range <sup>1</sup>                  | 5E-7 to 1E-3 Torr (6.6E-7 to 1.3E-3 mbar)           |                                       |                                       |
| Total pressure accuracy <sup>2</sup>               | $\pm$ 25% 1E-6 to 1E-3 Torr (1.3E-6 to 1.3E-3 mbar) |                                       |                                       |
| Maximum ion source operating pressure <sup>3</sup> | 1E-3 Torr (1.3E-3 mbar)                             |                                       |                                       |
| Nominal ion source operating pressure <sup>4</sup> | 2E-4 Torr (2.6E-4 mbar)                             |                                       |                                       |
| System operating pressure (with orifices)          | 1E-8 Torr (1.3E-8 mbar) to 912 Torr (1216 mbar)     |                                       |                                       |
| Sensitivity at low emission, FC mode               | >4.0E-6 amps/Torr (>3E-6 amps/mbar)                 | >2.0E-6 amps/Torr (>1.5E-6 amps/mbar) | >1.0E-6 amps/Torr (7.6E-7 amps/mbar)  |
| Sensitivity at high emission, FC mode              | >2.0E-5 amps/Torr (>1.5E-5 amps/mbar)               | >1.0E05 amps/Torr (>7.6E-6 amps/mbar) | >5.0E-6 amps/Torr (>3.8E-6 amps/mbar) |
| Maximum data rate (analog scans or selected peaks) | 1.8 ms per point (555 data points per second)       |                                       |                                       |
| Abundance sensitivity <sup>6</sup>                 | <5 ppm                                              | <10 ppm                               | <100 ppm                              |
| Zero blast <sup>7</sup>                            | <1 ppm                                              | <15 ppm                               | <100 ppm                              |
| Detection limit <sup>8</sup>                       | <10 ppb                                             | <25 ppb                               | <50 ppb                               |
| Linearity                                          | $\pm$ 20%                                           |                                       |                                       |
| Minimum background pressure                        | <1.0E-8 Torr (<1.3E-8 mbar)                         |                                       |                                       |
| Maximum sensor and inlet operating temperature     | manifold: 120°C, inlet: 180°C                       |                                       |                                       |

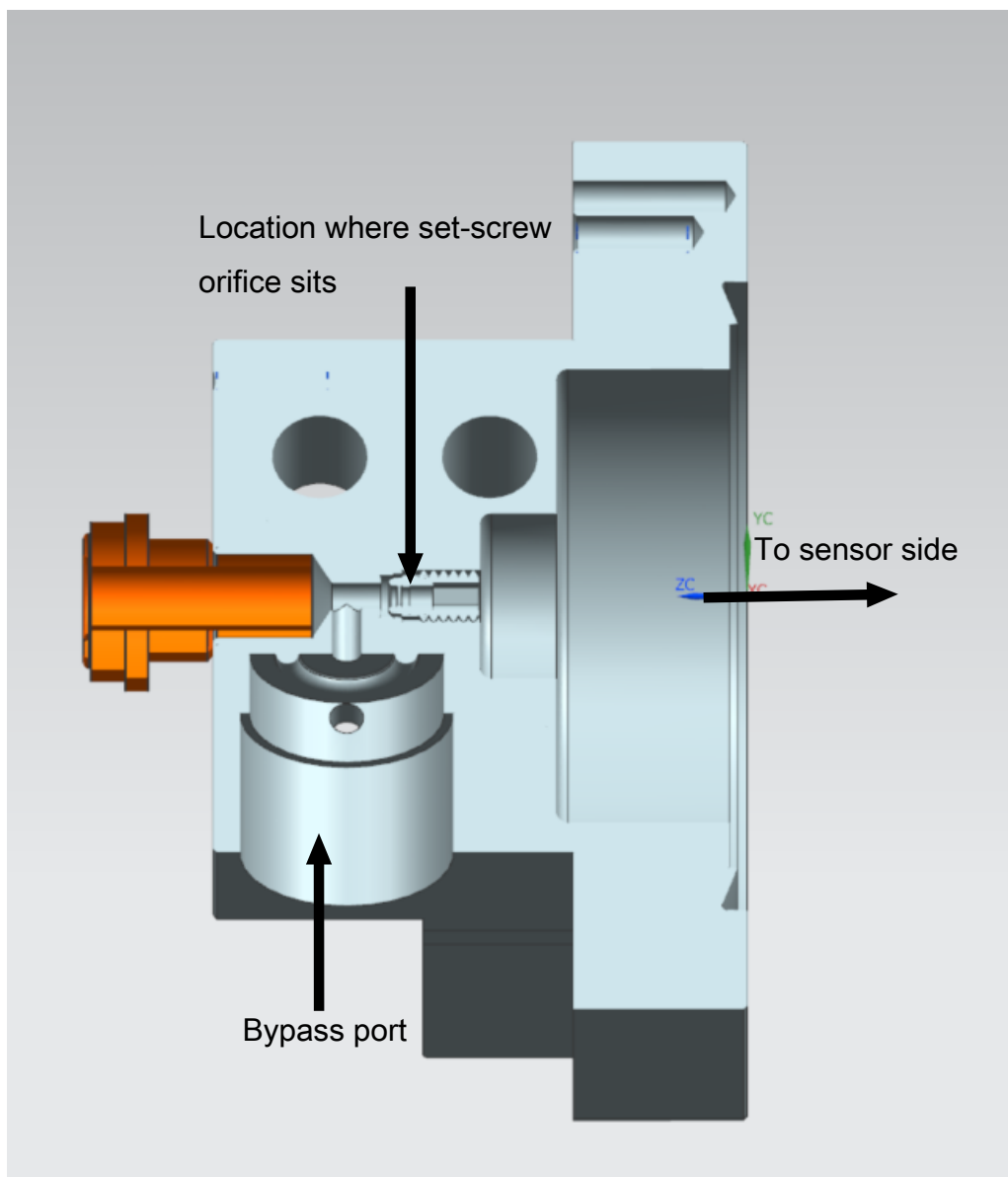
1. The pressure reading at low emission using a total pressure lens.
2. The total pressure accuracy at low emission.
3. The maximum ion source operating pressure at low emission (the filament turn-off threshold).

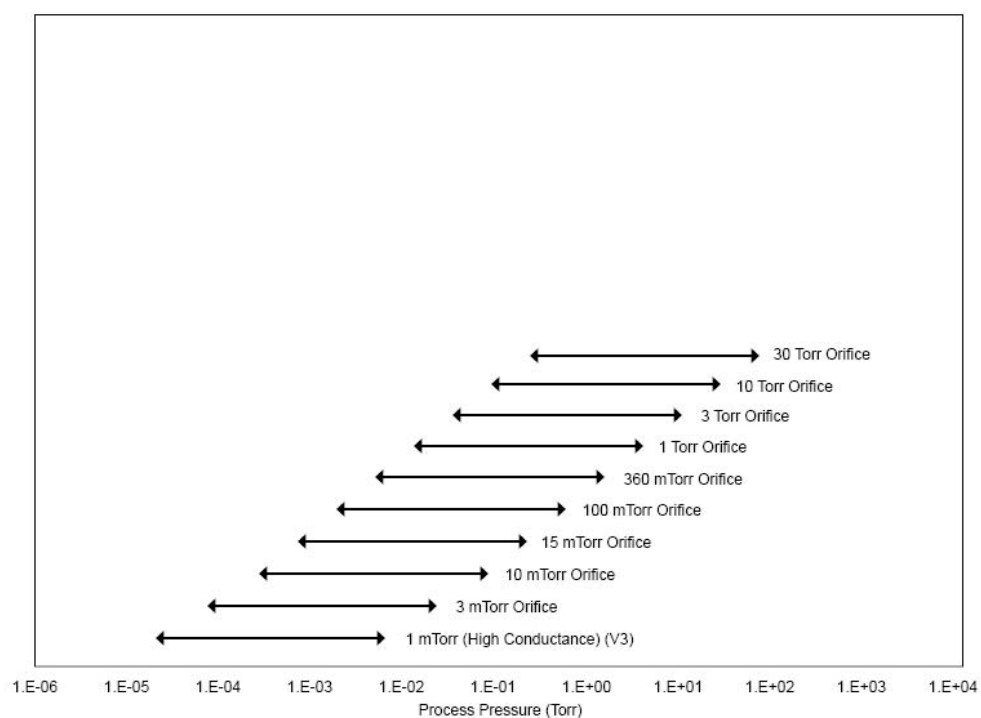
4.  $2\text{E-}4$  Torr ( $2.6\text{E-}4$  mbar) in the closed ion source produces  $1\text{E-}5$  Torr ( $1.3\text{E-}5$  mbar) in the quadrupole region.
5. The mass 40 contribution onto 41 amu.
6. The zero blast contribution onto 2 amu.
7. The minimum detectable concentration with krypton in air at a two second dwell time.
8. The specification is for 1 Torr (1.33 mbar) orifices and lower. This is the linearity specification at low emission at 0.1 to 2 times the nominal orifice pressure.

## 7.4.2 Single Pressure Inlet



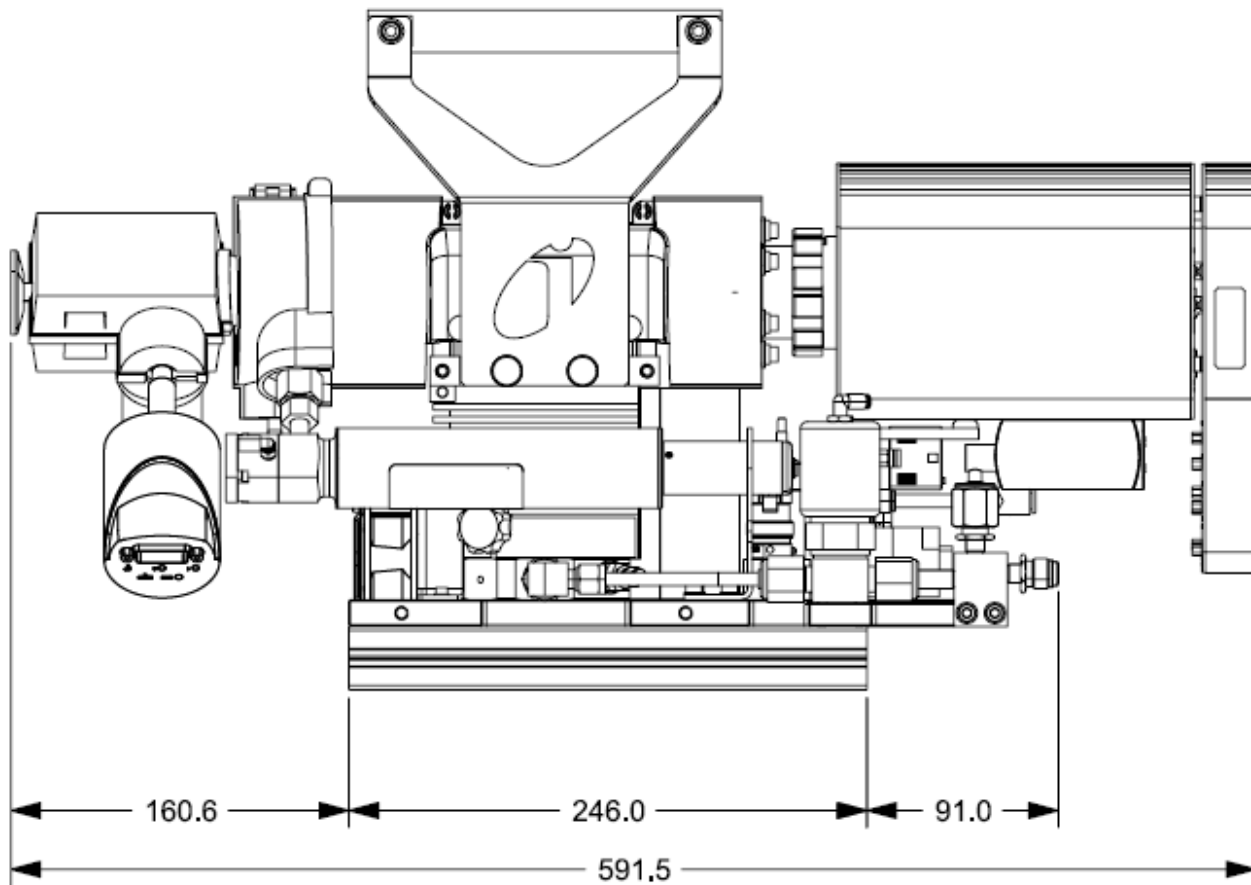
For 1 Torr orifices and lower. Linearity at low emission at 0.1 to 2 times the nominal orifice pressure.

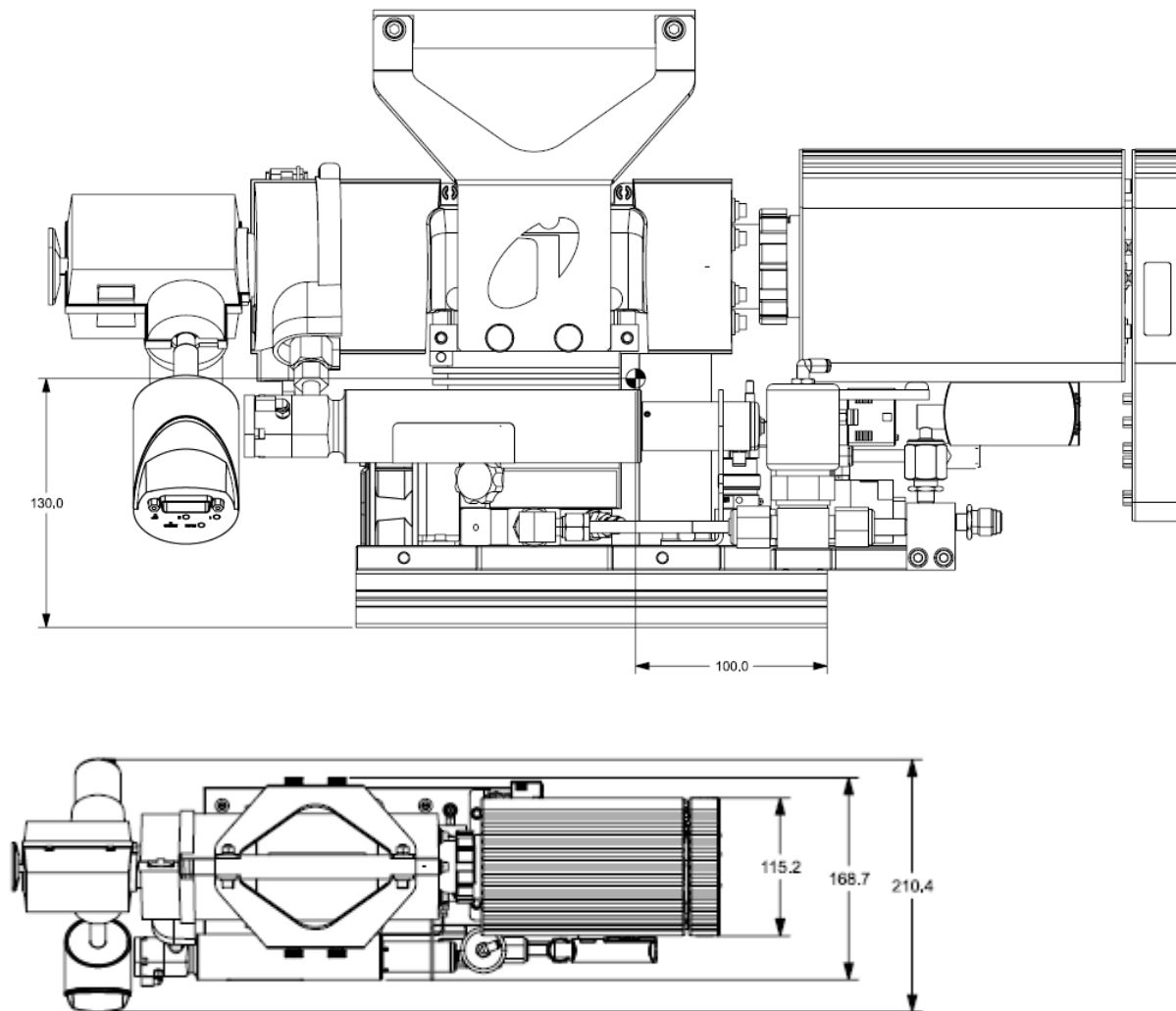


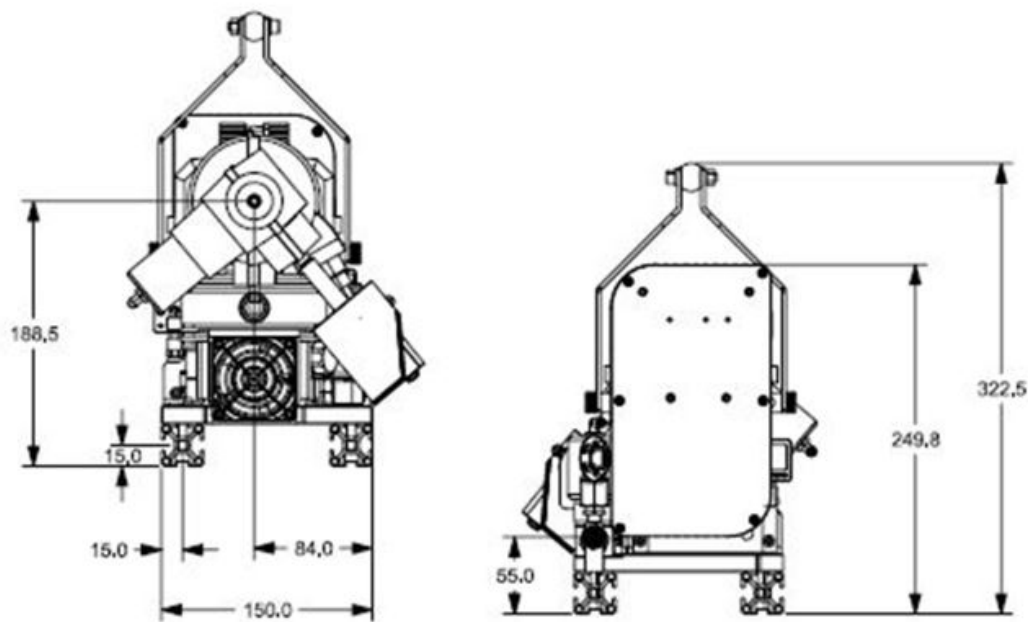


## 7.5 Physical Specifications

### 7.5.1 Physical Dimensions







System dimensions: 23.28 in. x 8.28 in. x 12.7 in. ( 591.5 mm x 210.4 mm x 322.5 mm)

Foreline pump dimensions: 8.6 in. x 5.9 in. x 5.8 in. (218 mm x 150 mm x 147 mm)

### 7.5.2 Weight

The approximate weight of Transpector APX ALD (without the foreline pump) is 32 lbs (14.5 kg).



The weight includes all connecting cables.

### 7.5.3 Ventilation Requirements

If enclosing Transpector APX ALD, the enclosure must be large enough or ventilated to provide adequate cooling airflow to the fan on the Transpector APX ALD pumping system.



#### **⚠ CAUTION**

**For adequate ventilation, maintain at least 1 in. (25.4 mm) clearance around the Transpector APX ALD electronics module, the Transpector APX ALD heaters and the pumping system.**

## 7.5.4 Electrical Power Requirements

The Transpector APX ALD system components that require AC power input are:

- Transpector APX ALD: use a universal input. Any voltage in the range specified in Acceptable Supply Voltage Range [▶ 24] is acceptable.
- Personal computer: use a universal input. Any voltage in the range specified in Acceptable Supply Voltage Range [▶ 24] is acceptable.

### 7.5.4.1 Required Supply Voltage

AC power input is required. The AC input voltage is supplied and regulated through the external power brick as shown below.



The power brick is certified/qualified for:

DoE level VI efficiency

Medical & ITE Certifications

Class I

Less than 0.5 W off-load power draw

IEC60601-1-2 Ed4 & 60601-1-11

Suitable for B & RF rated equipment

Output cable and connector

Two meter output cable with power D connector

#### 7.5.4.1.1 Acceptable Supply Voltage Range

The AC voltage input must be within 90 - 264 V (ac).

#### 7.5.4.1.2 Required Frequency

The required frequency of the AC input power is 47 - 63 Hz.

#### 7.5.4.1.3 Power Rating

The electronics module (electronics box and vacuum system interface) regulates all necessary currents for operation of all major components such as foreline pump, turbomolecular pump, and all cartridge heaters. The supplied voltage to those components is regulated at 24 Volts by the electronics box. Therefore, each component will require a different draw current at different states.

The rating of the current drawn by the Transpector APX ALD's external power supply is 3 A maximum at 115 V (ac).

Power factor: Meets EN61000-3-2, >0.9 at 230 V (ac) full load.

#### 7.5.4.1.4 Overvoltage Category

Overload & short circuit protection: 105 - 150% - hiccup mode.

Over-voltage protection: Auto recovery.

#### 7.5.4.1.5 Electrical Connections

The electrical connections are a 110 V (ac), three-pronged, grounded plug or a 230 V (ac), two-pronged plug with a ground contact. The plug can be US, UK, European or Israel plug type.

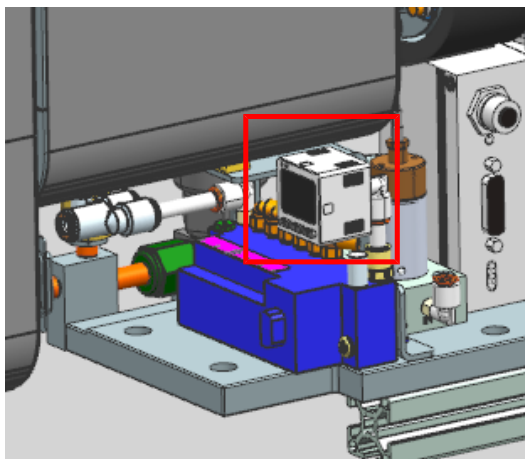


#### CAUTION

Do not replace the power cord with an inadequately rated cord. The cord must be rated 10 A or higher.

## 7.6 Nitrogen Purge Gas (Corrosive System Only)

Nitrogen is recommended to use as the purge gas for corrosive pumping systems. The corrosive pumping system provides  $8.5 \pm 1$  sccm of nitrogen purge gas to flow through its bearings to protect the bearings from corrosion and loss of lubricant by evaporation. For the corrosive pumping system, nitrogen gas is routed directly to the solenoid valve block and to the pressure regulator through a 1/4 in. (6.35 mm) tee. The supplied pressure is displayed on an LCD screen, attached to the solenoid. The location of the pressure switch is indicated in the illustration below.



The pressure switch is rated for 58 up to 120 psi (4–8.27 bar) [400–827 kPa]. The recommended supply pressure is 75–80 psi (gauge) (5.17 to 5.52 bar) [517 kPa to 552 kPa].



### CAUTION

**The nitrogen pressure must be at least 58 psi (4 bar) [400 kPa] and must not exceed 120 psi (8.89 bar) [889 kPa]**

## 7.7 Exhaust Gas

Exhausting gas from the turbomolecular pump is required for corrosive applications. If sampling toxic gas chemistries it is essential that the exhaust port of the turbomolecular pump be connected to an abatement system at the factory. With non-corrosive applications, exhaust the turbomolecular pump in accordance with the facility's requirements. The dry foreline pump has a 1/4 in. (6.35 mm) male VCR connection.

## 7.8 Vacuum Requirements

### 7.8.1 Required Vacuum

Transpector APX ALD requires a combination of foreline pump and turbomolecular pump to create the vacuum conditions necessary for proper operation. The turbomolecular pump is always included with the system. The foreline pump is optional for user to select. If user selects no foreline pump, in that case, user has to utilize the foreline pump of their tool, which the Transpector APX ALD is integrated on.

During initial pumpdown, the foreline pump and turbomolecular pump start pumping simultaneously. The foreline pump evacuates the residual gas inside the foreline hose that connects to the system at the exhaust port. The Pirani gauge monitors the pressure at the exhaust port, also known as foreline pressure. Once the pressure reading of the Pirani gauge is below 12 Torr (16 mbar), the foreline isolation valve will open and the residual gas inside the manifold will be evacuated by the turbomolecular pump and foreline pump. If the foreline pump is not able to bring the foreline pressure from atmospheric pressure down below 12 Torr (16 mbar) within 12 seconds, the firmware will trigger a shutdown by closing the foreline isolation valve, stop the foreline pump and stop turbomolecular pump acceleration. If the foreline pump is the tool foreline pump, the firmware closes the foreline isolation valve and stops turbomolecular pump acceleration. When such a shutdown happens, the user is required to execute initial pumpdown again in the control software.

When the foreline isolation valve is open, and the foreline pressure is kept under 12 Torr (16 mbar), the turbomolecular pump will accelerate to its maximum speed of 90,000 revolutions per minute (rpm). Once the turbomolecular pump reaches the maximum speed and emission is turned on, the initial pumpdown is completed and the user can begin operating the system.

### 7.8.2 Acceptable Range Of Vacuum

The Transpector APX ALD manifold can achieve  $<1 \times 10^{-8}$  Torr ( $1.3 \times 10^{-8}$  mbar) of base pressure (when there is no sample flow) after bakeout and cool down. This level of vacuum requires a foreline pressure of  $<12$  Torr (16 mbar).

## 7.9 Air Pressure Requirements

### 7.9.1 Required Air Pressure

Dry compressed air (or dry nitrogen) is used to operate the electro-pneumatic inlet valves. The inlet valves are pneumatically driven valves. The pilot valves are electrically driven valves.

The minimum air pressure required to operate the inlet valves is 58 psi (gauge) (4 bar) [400 kPa] and the maximum air pressure required to operate the inlet valve is 120 psi (gauge) (8.27 bar) [827 kPa]. The recommended setting is 75-80 psi (gauge) (5.17 to 5.52 bar) [517 kPa to 552 kPa].

## 7.9.2 Air Pressure Range

The air pressure range is 59–120 psi (gauge) (4 - 8.27 bar) [400–827 kPa]. The recommended setting is 75-80 psi (gauge) (5.17 to 5.52 bar) [517 to 552 kPa].



### **⚠ CAUTION**

**The air pressure must not exceed 120 psi (gauge) (8.27 bar) [827 kPa].  
The air pressure must be at least 59 psi (gauge) (4 bar) [400 kPa].**

## 7.9.3 Moisture Content of Compressed Air Supply

The compressed air supply used for inlet valve operation must be dried to the extent that changes in compressed air pressure during operation will not produce condensation in lines, solenoids or valve actuators.



### **⚠ CAUTION**

**Moisture condensation can cause corrosion.**

## 7.9.4 Air Pressure Connections

The compressed air supply connects to Transpector APX ALD solenoid with a 1/4 in. (6.35 mm) polymer hose. The 6.35 mm (1/4 in.) connector is a friction-lock, right-angle fitting to adapt the supply hose to the solenoid base.

# 7.10 Environmental Requirements

## 7.10.1 Use

The instrument is for indoor use only.

## 7.10.2 Altitude Range

The instrument can be used up to an altitude of 6561 ft. (2000 m). Contact INFICON for operating instructions at higher altitudes.

### 7.10.3 Maximum Humidity

The instrument can be used up to 80% relative humidity (no condensation).

### 7.10.4 Pollution Degree

The instrument can be used at a pollution degree of 2 (per EN61010-1:2001).

### 7.10.5 Maximum Operating Temperature

The maximum ambient operating temperature is 35°C (95 °F).

### 7.10.6 Minimum Operating Temperature

The minimum operating temperature is 5°C (41°F).

### 7.10.7 Clean Room Requirements

Transpector APX ALD is clean room compatible.

### 7.10.8 Anti-Static Conditions

Transpector APX ALD passes standard EN 61326-1:2013.

## 7.11 Computer System Requirements

The minimum system requirements for FabGuard Explorer Operating Software are listed here:

| Parameter        | FabGuard Node Requirements                                        |
|------------------|-------------------------------------------------------------------|
| Processor        | 4.0+ GHz Quad core                                                |
| Memory           | 16+ GB Recommended                                                |
| Hard drive       | DATA 500 GB to 1 TB SSD                                           |
| Resolution       | 1024 x 768 16-bit color or greater                                |
| Ethernet port    | One free Ethernet port to allow connection to Transpector APX ALD |
| Operating system | Windows® 7 or 10                                                  |

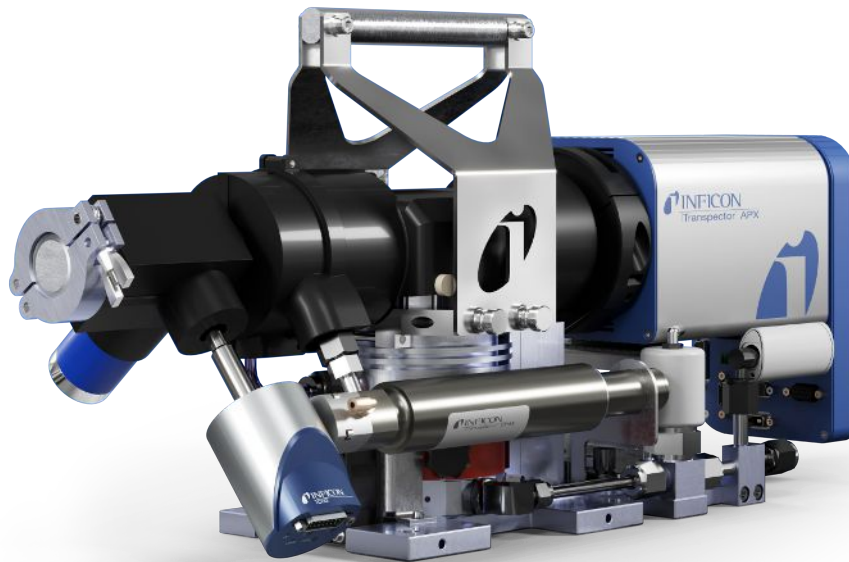
INFICON can supply a controller to run the software that operates Transpector APX ALD.

## 7.11.1 Operating System

FabGuard software requires either Windows 7 or Windows 10 for proper operation.

## 8 Installation

The Transpector APX ALD system is shipped with the electronics module attached to the sensor module as shown, and sandwiched between two plastic panels. If the system includes the foreline hose and/or the diaphragm foreline pump, these will be packaged separately. All the connecting cables from the VSI will be installed in the designated ports at the factory prior to shipping.



- 1 Mount Transpector APX ALD to the process tool, if applicable.
- 2 Install the Transpector APX ALD foreline pump, if included.
- 3 Install pneumatic supply gas and purge gas, if applicable.
- 4 Install FabGuard software.
- 5 Establish communication between the Transpector APX ALD and FabGuard.
- 6 Pump down the Transpector APX ALD.



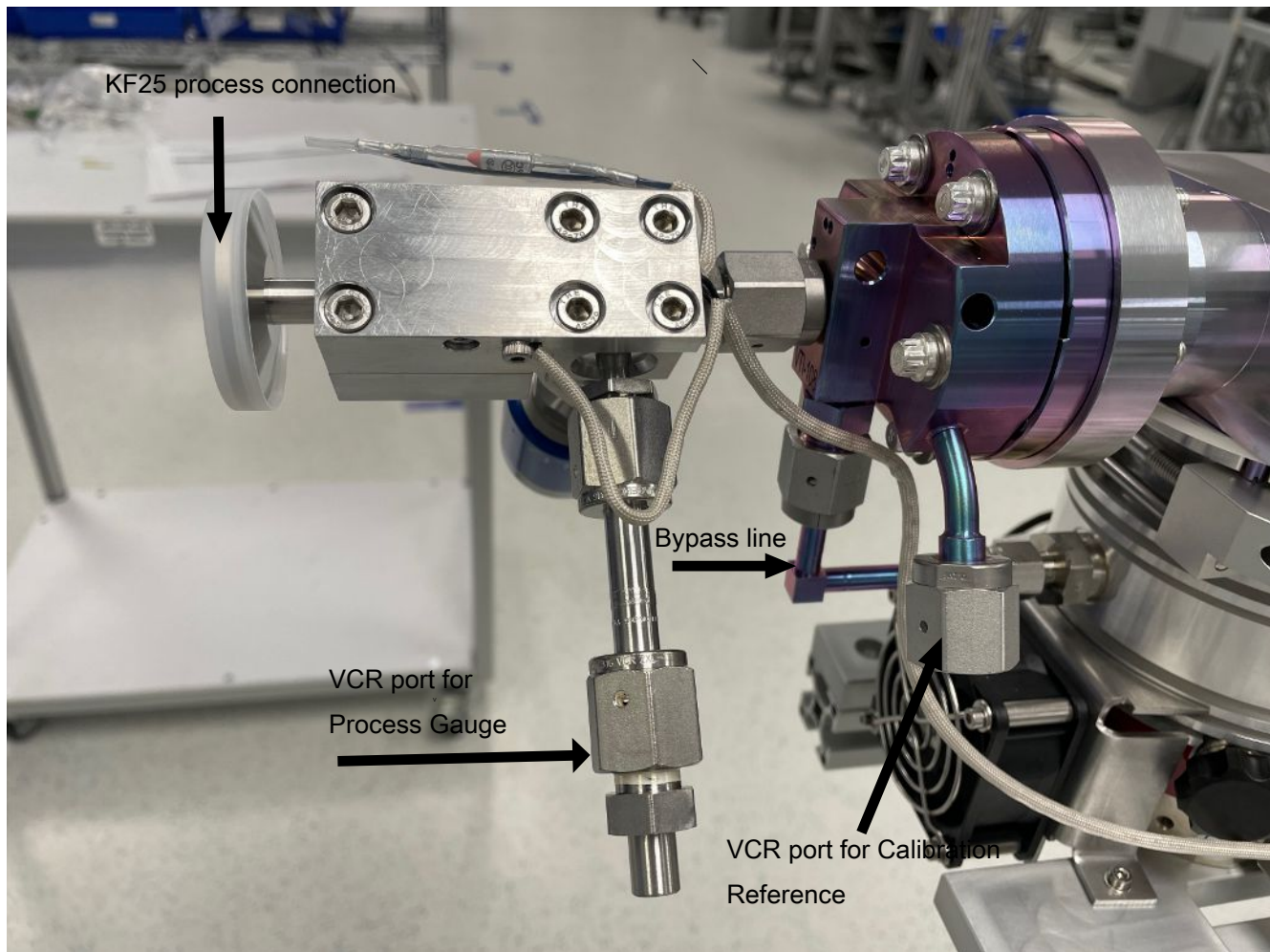
**Lint free gloves should be worn whenever installing or maintaining vacuum components to avoid impacting vacuum cleanliness.**

## 8.1 Ambient Temperature Requirements

The Transpector APX ALD electronics module must be mounted in an area where the ambient temperature does not exceed 35°C (95°F) and there is ample air flow. The best performance is achieved when the electronics module is not exposed to wide temperature variations.

## 8.2 Inlet installation

Transpector APX ALD comes with KF25 process connection as default.  
See picture below.



## 8.3 Mount the Pumping System

Transpector APX ALD has a KF25 as default process connection. If chamber has a different connection type, an adapter with KF 25 at one end is required. Normally there is no need to use an additional isolation valve between system and the process chamber.

Transpector APX ALD has an ALD isolation valve and a CDG gauge for inlet interlock. It is essential to pump down the volume between the isolation valve from the process side and the ALD isolation valve before turning emission on.

**⚠ CAUTION**

**If an isolation valve is used, ensure any trapped volumes are pumped out in order to avoid filament failure.**

A support kit is supplied for Transpector APX ALD configurations with a standard process connection. The support kit, PN 922-209-G1, consists of two 4 ft. (1.22 m.) support legs, two adjustable feet and mounting hardware.

**⚠ CAUTION**

**When installing Transpector APX ALD, make sure it is properly secured in case of a seismic event.**

### 8.3.1 Install the Support Kit

- ✓ Two Bosch rails underneath the system baseplate are designed to support installation. Support legs can be attached to these Bosch rails with provided hardware.
- ✓ Measure the support leg to make sure that there is ample room for installation. The legs may be cut to size. One end of the support leg has a threaded hole for an adjustable foot. When cutting the leg, make sure that the threaded hole end is used for the support.
  - 1 Screw the adjustable foot fully into the bottom of the support leg.
  - 2 Install the right-angle bracket onto the support leg using the T-nut and bolts provided. Finger-tighten the bolt.
  - 3 Install the second bolt and T-nut into the bracket, leaving it loose.
  - 4 Slide the T-nut into the Transpector APX ALD mounting rail slot and adjust the position of the leg so that it is perpendicular to the floor with the adjustable foot about 1/2 in. (12.7 mm) from the floor.
  - 5 Tighten all of the hardware.
  - 6 Install the safety cap.
  - 7 Unscrew the adjustable foot until it supports Transpector APX ALD and relieves pressure from the flange.
  - 8 Tighten the lock nut on the adjustable foot against the support leg.

## 8.4 Foreline Pump Installation

The 24 V (dc) dry foreline pump has the following connections:

- An electrical connection to the Transpector APX ALD vacuum system interface.
- A foreline hose connection to the foreline isolation valve/Pirani assembly connection.
- An exhaust port connection. This connection is required for corrosive or toxic gas sampling. Refer to the appropriate standards, such as SEMI S6-0707E, for exhaust gas guidelines.



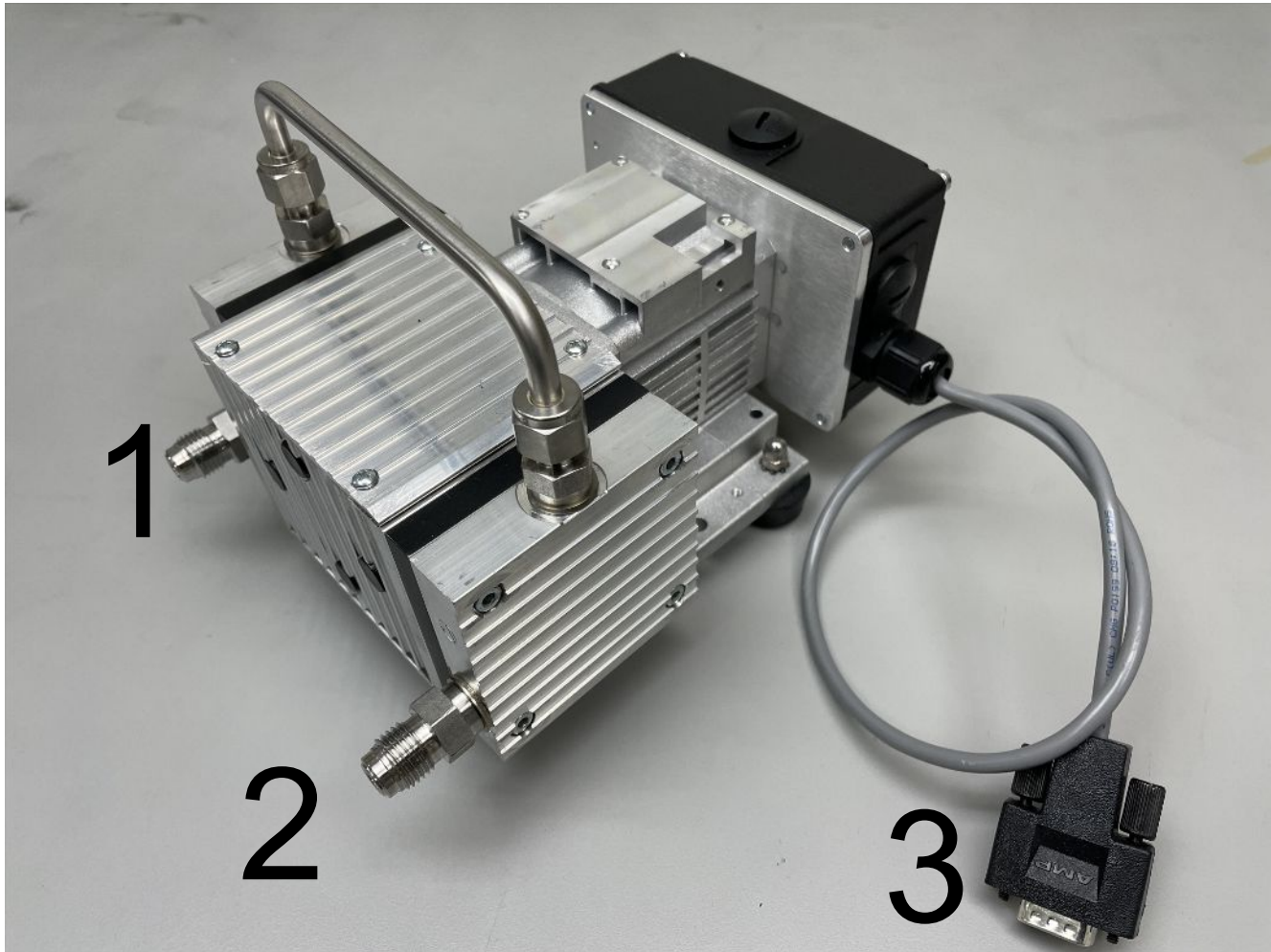
### **WARNING**

**Proper exhaust connections must be installed when sampling toxic, corrosive or any hazardous gases to protect the environment from lethal levels of gas.**



### **CAUTION**

**If a customer-supplied foreline pump is used, it must provide a continuous pressure below 12 Torr (16 mbar).**



|   |              |   |                     |   |                      |
|---|--------------|---|---------------------|---|----------------------|
| 1 | exhaust port | 2 | foreline connection | 3 | foreline power cable |
|---|--------------|---|---------------------|---|----------------------|

## 8.5 Software Installation

Refer to the FabGuard Operating Manual for information regarding software installation.

## 9 Connecting the Instrument

The Transpector APX ALD communicates via Ethernet. Devices on an Ethernet network have two identifying addresses: an IP address and a MAC address.

- IP addresses are assigned to identify individual devices on a network. Each device on an Ethernet network, including the host computer, must have a unique IP address. IP addresses can be reassigned to other devices on the network as long as each device has a unique IP address.
- MAC addresses are unique for each device. MAC addresses are never duplicated.

### 9.1 General Networking Information

#### 9.1.1 IP Addresses

IP addresses can be either static or dynamic.

- Static (manual) IP addresses are set by the user and are changeable by the user. Static IP addresses are preferred.
- Dynamic (automatic) IP addresses are automatically set by a host or by a server on a network. Dynamic IP addresses can be set through dynamic host communication protocol (DHCP).



When using static IP addresses on a large network (for example, on a company network), a block of addresses should be reserved for static IP address use and prohibited from being assigned by the DHCP server (host). This will avoid duplicate IP address conflicts.



#### CAUTION

**Use static IP addresses with Transpector APX ALD. Using DHCP, the host server may generate a new IP address if Transpector APX ALD is taken offline and then returned online, or if there is an IP address conflict on the network.**

If the Transpector APX ALD IP address is randomly changed during data acquisition, FabGuard will not reconnect to the new sensor IP address. This will result in a loss of communication and a loss of data.

---

Transpector APX ALD follows the IPv4 IP address convention. An example IP address is **192.168.1.100**. Each of the four parts is referred to as an “octet.” The IP address consists of a network prefix and a host protocol.

### 9.1.2 Subnetworking

An IP network can be split into multiple subnets. Subnetting sets a region of the IP address as a network prefix for all IP addresses inside the subnet through a subnet mask. The subnet mask determines which octets of the IP address are used as the network prefix.

In order for two network devices to communicate, they must be on the same subnet, be connected to the same internet network and have the same network prefix.



If two devices have different network prefixes, the two devices are on different subnets.

|                | Example 1     | Example 2     | Example 3       |
|----------------|---------------|---------------|-----------------|
| IP address     | 192.168.1.104 | 192.168.1.105 | 192.168.1.150   |
| Subnet mask    | 255.255.255.0 | 255.255.0.0   | 255.255.255.192 |
| Network prefix | 192.168.1.0   | 192.168.0.0   | 192.168.1.128   |
| Host protocol  | 0.0.0.104     | 0.0.1.105     | 0.0.0.22        |

## 9.2 IP Address

The default Transpector APX ALD IP address is 192.168.1.100 with a subnet mask of 255.255.0.0.



When connecting to an existing local network, there must be a static IP address for each Transpector APX ALD RGA. Contact the network administrator for IP address assignments.

Two methods of changing the Transpector APX ALD IP address are available:

- INFICON Mass Spectrometer Search Utility
- Transpector APX ALD Web UI

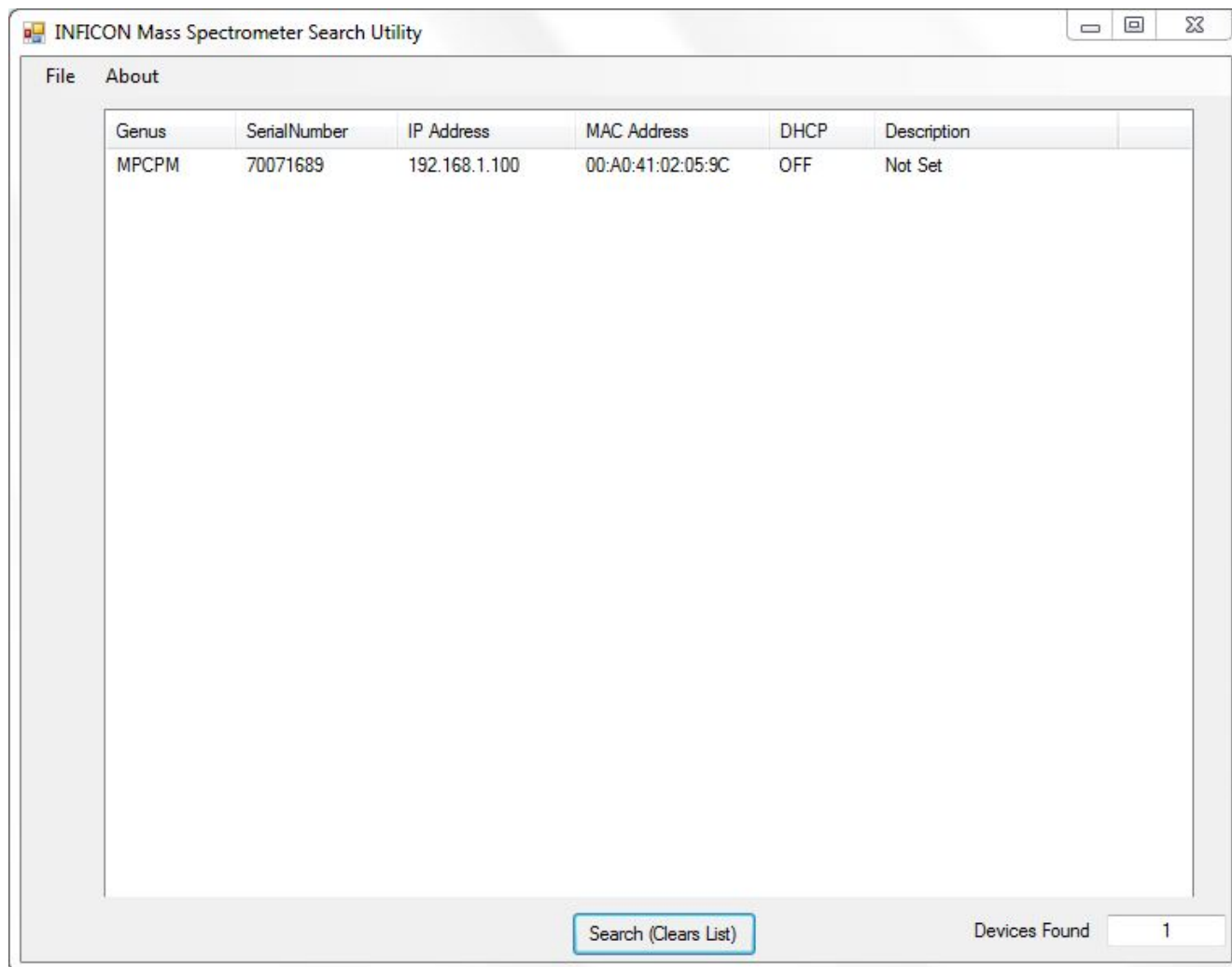
### 9.2.1 Use the INFICON Mass Spectrometer Search Utility to Change the IP Address

The INFICON Mass Spectrometer Search Utility (IMSSU) is included with FabGuard Explorer software. Once the FabGuard Explorer software is installed onto the host computer, the user can find the INFICONMassSpecSearch.exe installer file in the directory [C:\Inficon].

> OS (C:) > Inficon

| Name                              | Type        |
|-----------------------------------|-------------|
| FgAutoStartProgramAcquisition.exe | Application |
| FgAutoStartProgramExecutive.exe   | Application |
| HTMLConverterX.exe                | Application |
| INFICONMassSpecSearch.exe         | Application |

Right click the file and select "Run as Administrator" to install the application software.  
The IMSSU opens as shown below.

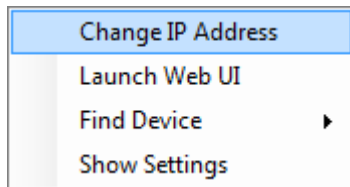


The IMSSU detects every Transpector APX ALD RGA installed on the network regardless of IP address. The IMSSU runs automatically, and can be manually started or restarted by clicking **Search (Clears List)**. The display shows:

- **Genus** (MPCPM for Transpector APX ALD sensors)
- **Serial Number**
- **Current IP Address**
- **MAC Address**

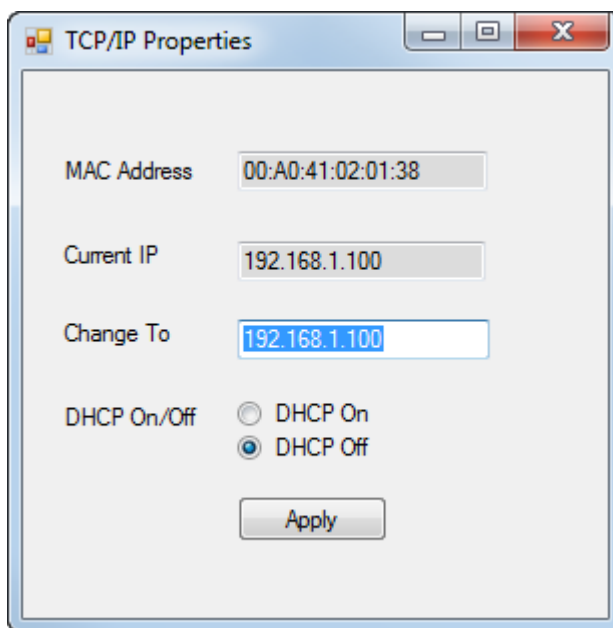
- **DHCP** status (On or Off)
- **Description** (user editable)

Right-click on a sensor to display the menu.



### 9.2.1.1 Change IP address

- 1 Right-click on the sensor and select **Change IP Address**. The **TCP/IP Properties** window displays. The **TCP/IP Properties** window displays the:
  - ⇒ Transpector APX ALD **MAC Address**
  - ⇒ Transpector APX ALD **IP address**
  - ⇒ **Change To** text box, to enter a new Transpector APX ALD IP address
  - ⇒ **DHCP On** or **DHCP Off** selection



#### ⚠ CAUTION

**Set DHCP Off so the IP address cannot be automatically reassigned.**

- 2 Type the new IP address in the **Change To** text box.
- 3 Click **Apply**. Transpector APX ALD automatically reboots and returns online with the new IP address.
- 4 Launch the Web UI.

### 9.2.1.2 Launch Web UI

Transpector APX ALD Web UI can be launched from inside the IMSSU. Refer to the 074-581-P1 Transpector Web UI Operating Manual for instructions.

### 9.2.1.3 Find the Device

**Find Device On** flashes the power indicator on the device. The indicator flashes for up to 60 seconds and then illuminates.

**Find Device Off** selected within 60 seconds after selecting **Find Device On** stops the search.

### 9.2.1.4 Show Settings

Click **Show Settings** to display multiple settings useful for troubleshooting. The display shows:

- serial number
- gateway
- IP address
- DHCP status
- MAC address
- description
- subnet mask
- name
- description
- structure version
- box type
- port
- firmware version
- TCP/IP source

## 9.3 Connect the Instrument

Before connecting Transpector APX ALD, decide:

- Is Transpector APX ALD going to be on a private network (installed directly on either a computer or a router that is not hooked up to the internet) or an internal network where multiple computers are connected with access to the internet?
- Is more than one Transpector APX ALD sensor being installed at the same time?

## 9.3.1 Connect a Single Instrument

### 9.3.1.1 Single Sensor Direct Connection Installation

When installing a single Transpector APX ALD on a private network or connecting directly to a computer, changing the IP address of Transpector APX ALD is necessary only if the computer being used to connect to Transpector APX ALD has a different network prefix than Transpector APX ALD.

The default network prefix of Transpector is 192.168.x.x. The IP address of the host computer used to control Transpector APX ALD must have a subnet mask of 255.255.0.0 and a network prefix of 192.168.x.x.

If this is not the case, change the computer IP address to match the network prefix of Transpector APX ALD. For example, giving the computer an IP address of 192.168.1.101 allows Transpector APX ALD to communicate directly with the computer.

### 9.3.1.2 Install a Single Sensor on an Existing Local Network

When installing a single Transpector APX ALD on an existing local network, the default IP address of Transpector APX ALD may not be compatible with the network.

Transpector APX ALD can have either a static IP address (recommended) or a dynamic IP address set by DHCP (not recommended).

Contact the network administrator for information regarding valid IP addresses and ask the administrator to assign an IP address for Transpector APX ALD.

## 9.3.2 Install Multiple Sensors

Each Transpector APX ALD is shipped with an identical default IP address. When installing multiple Transpector APX ALDs, the IP address of each instrument must be changed one at a time so that each Transpector APX ALD has a unique IP address.



### CAUTION

**Do not connect multiple systems to a network without first changing the IP addresses. Otherwise, there will be IP address conflicts on the network.**

### 9.3.2.1 Install Multiple Sensors Directly to a Host Computer

A private local network must be created when multiple Transpector APX ALD sensors are connected to a single host computer instead of an existing local area network. Transpector APX ALD must be installed on either a router or Ethernet switch. The router or switch is connected to the host computer through the LAN port of the router/switch.

### 9.3.2.2 Install Multiple Sensors on an Existing Local Network

Use an Ethernet switch instead of a router when multiple Transpector APX ALD sensors are connected to an existing local network.



#### **⚠ CAUTION**

**Routers can cause conflicts with local networks because the router will attempt to set IP addresses for all network connected devices.**

Since Transpector APX ALD sensors are network connected devices, each sensor must have an IP address assigned to it by a network administrator. After changing each IP address manually, connect all of the sensors to the Ethernet switch and connect the switch to the local network.

## 9.4 Change the Computer IP Address

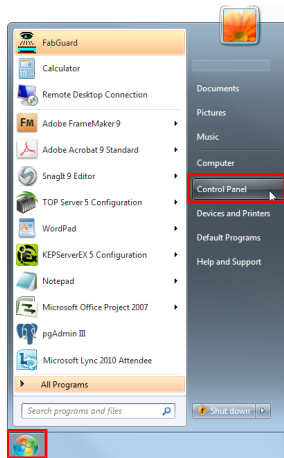
An alternative to changing the Transpector APX ALD IP address is to change the host computer's IP address to allow communication between the host computer and Transpector APX ALD.

The following sections will demonstrate how to change the host computer's IP address for Windows 7 and Windows 10.

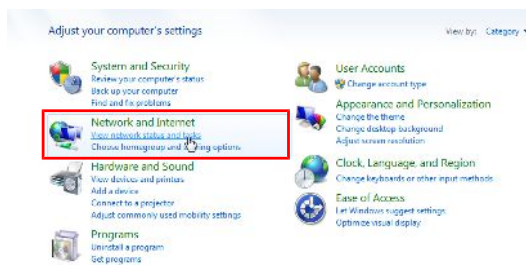
### 9.4.1 Windows 7

✓ Changing the IP address of the host computer requires administrator rights.

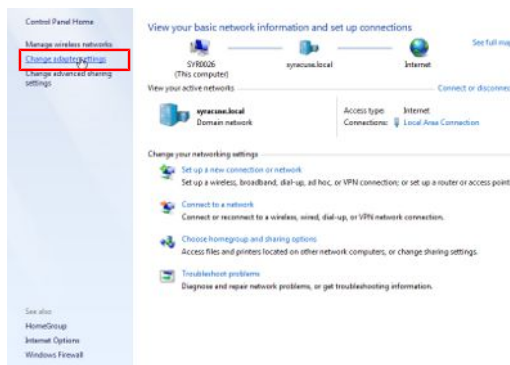
- 1 Click **Start**, then click **Control Panel**.



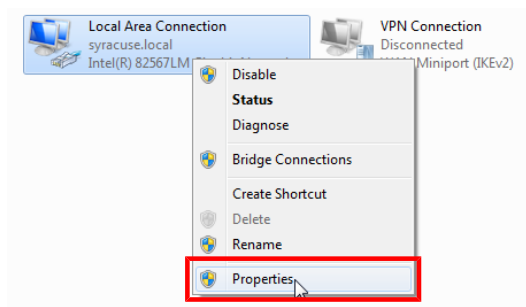
2 In the **Network and Internet** group, click **View network status and tasks**.



3 In the **Network Status and Tasks** window, click **Change adapter settings**.

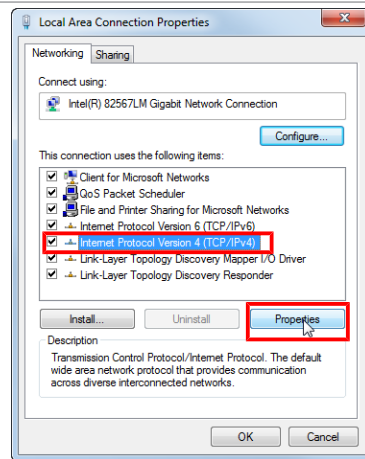


4 If the host computer is connected directly to Transpector APX ALD through the Ethernet port of the computer, right-click **Local Area Connection** and select **Properties**.

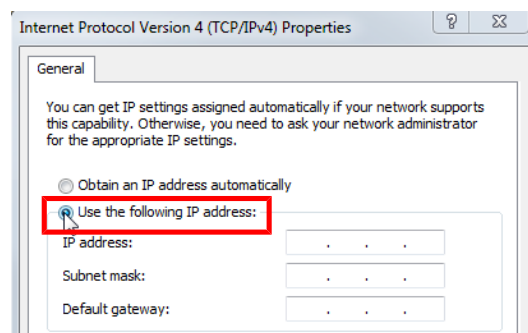


5 Click **Internet Protocol Version 4 (TCP/IPv4)**.

6 Click **Properties**.



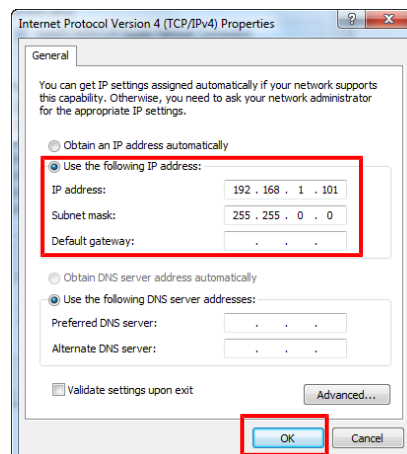
- 7** In the **Internet Protocol Version 4 (TCP/IPv4)** window, click **Use the following IP address**.



- 8** In the **IP address** field, type **192.168.1.XXX**. The last octet can be any number as long as it is unique to the network and is not the same as the Transpector APX ALD IP address.

- 9** In the **Subnet mask** field, type **255.255.0.0**.

- 10** Click **OK**.



⇒ The IP address is now set to the manual IP address chosen in step 7.

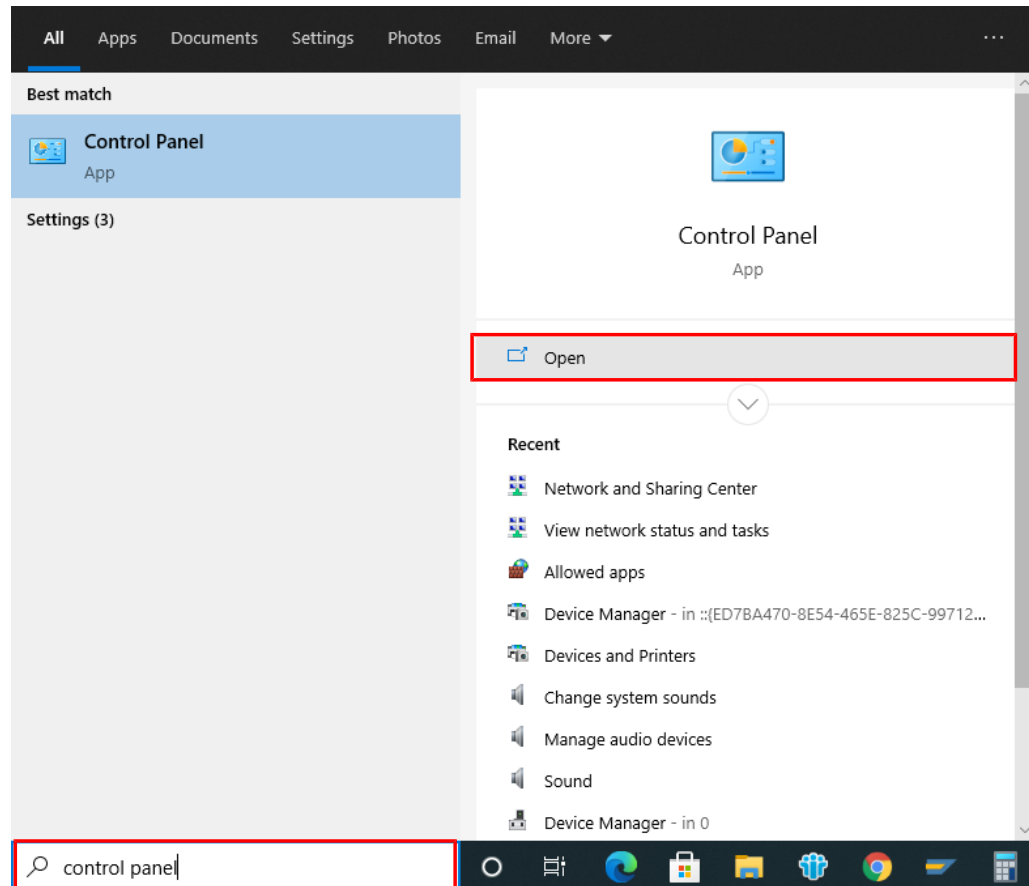
- 11** Exit from all of the windows.
- 12** Connect to Transpector APX ALD.

To change the IP address back to the default settings, follow steps 1 through 6 and reset the properties to their original settings.

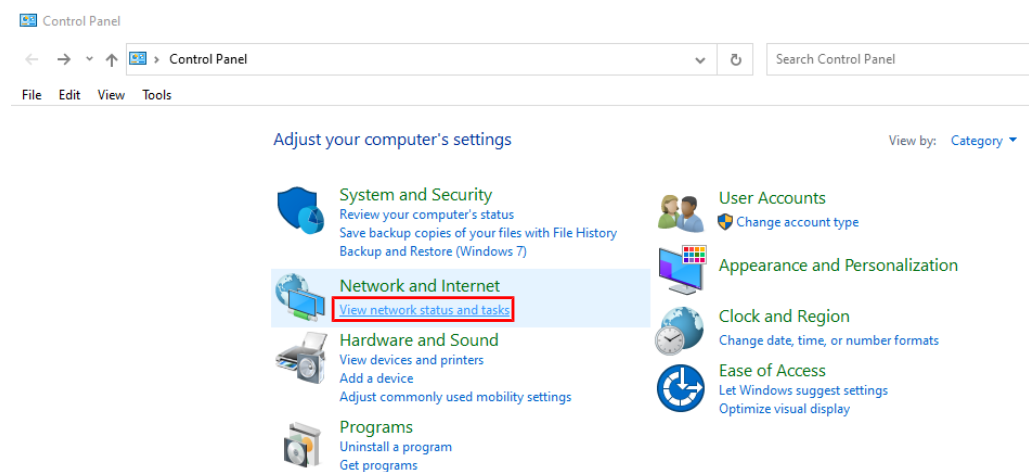
## 9.4.2 Windows 10

✓ Changing the IP address of the host computer requires administrator rights.

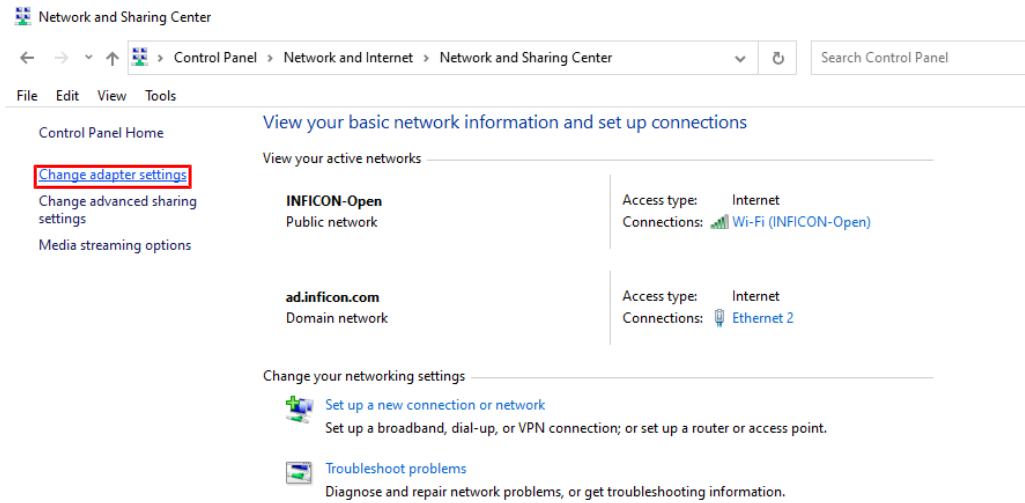
### 1 Search for **Control Panel**, then click **Open**



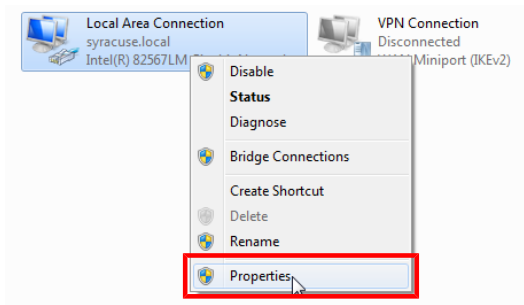
### 2 In the **Network and Internet** group, click **View network status and tasks**.



**3** In the **Network and Sharing Center** window, click **Change adapter settings**.

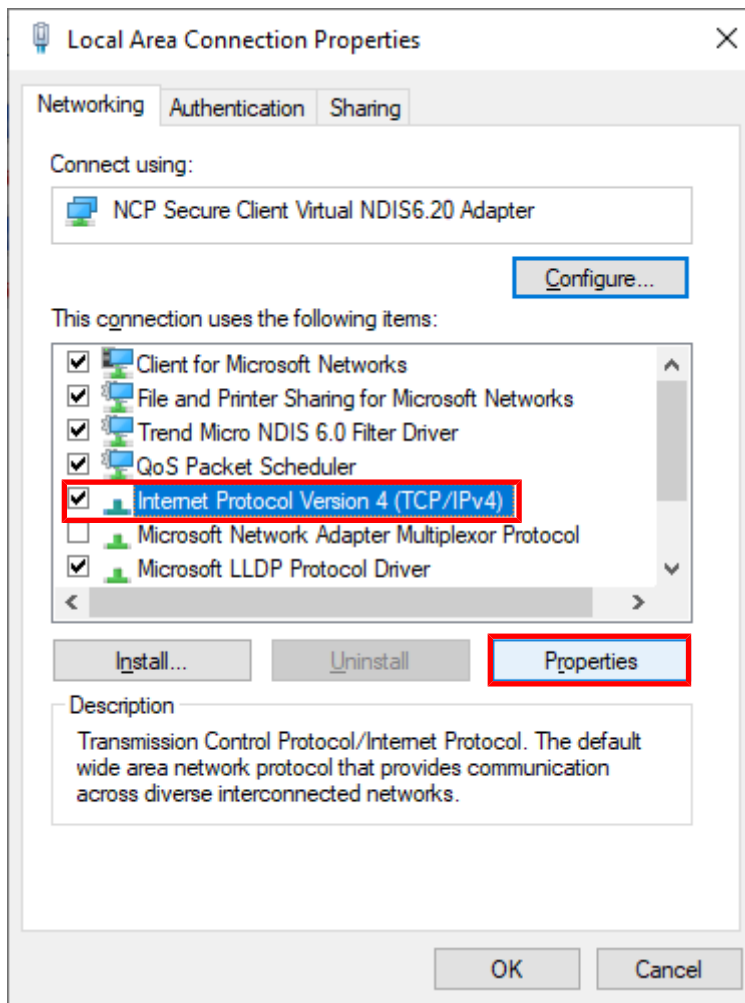


**4** If the host computer is connected directly to Transpector APX ALD through the Ethernet port of the computer, right-click **Local Area Connection** and select **Properties**.

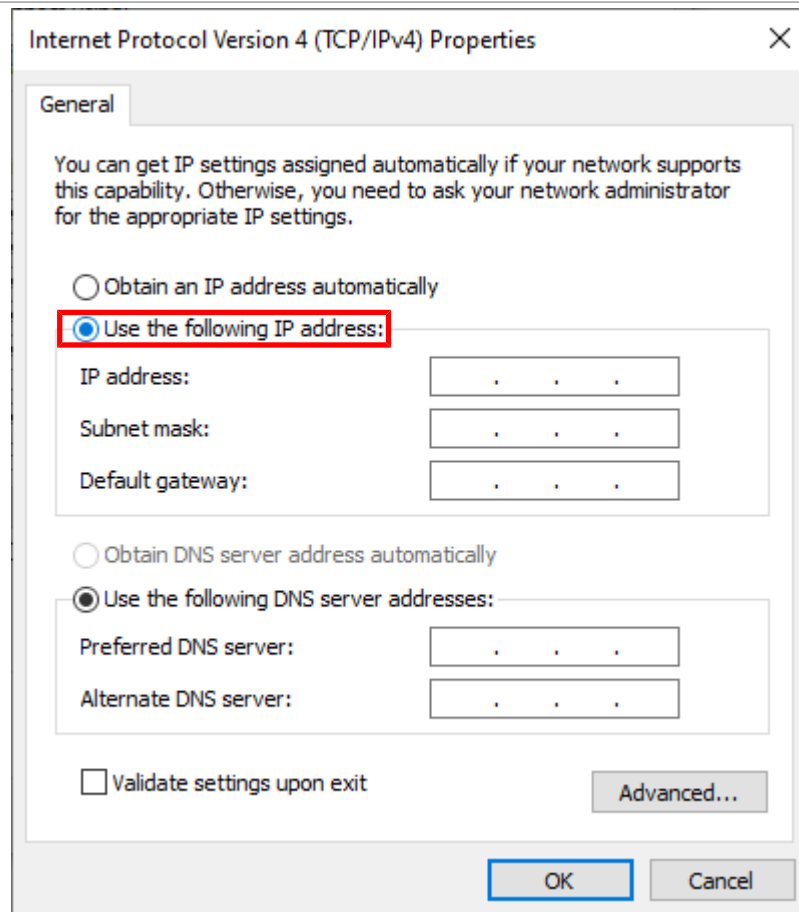


**5** Click **Internet Protocol Version 4 (TCP/IPv4)**.

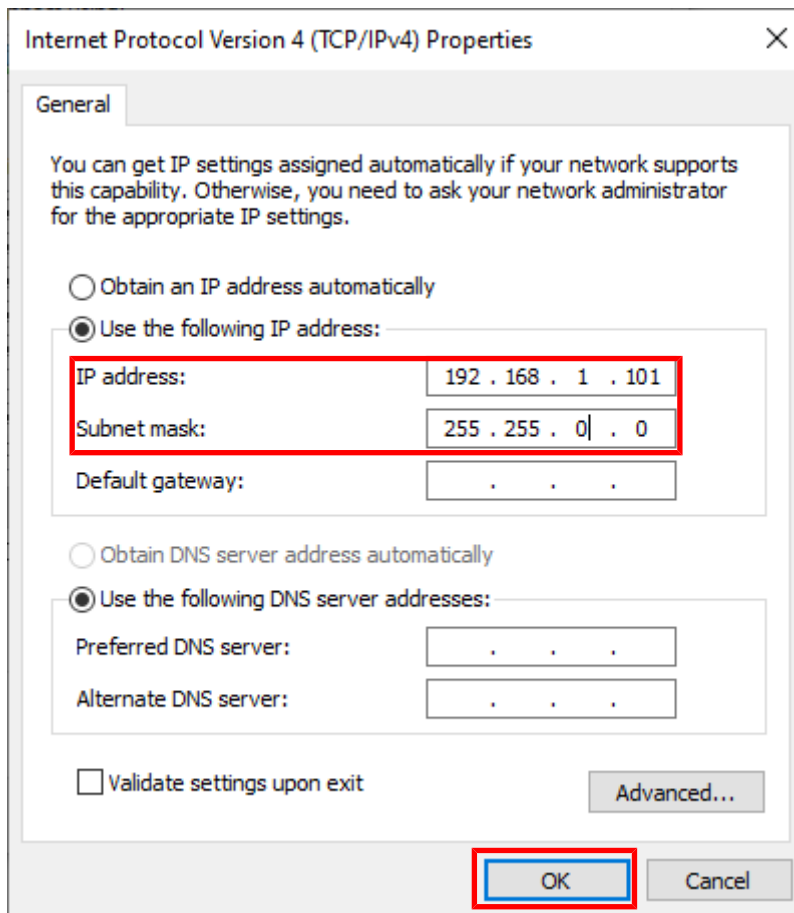
**6** Click **Properties**.



- 7 In the **Internet Protocol Version 4 (TCP/IPv4)** window, click **Use the following IP address**.



- 8 In the **IP address** field, type **192.168.1.XXX**. The last octet can be any number as long as it is unique to the network and is not the same as the Transpector APX ALD IP address.
- 9 In the **Subnet mask** field, type **255.255.0.0**.
- 10 Click **OK**.



⇒ The IP address is now set to the manual IP address chosen in step 7.

**11** Exit from all of the windows.

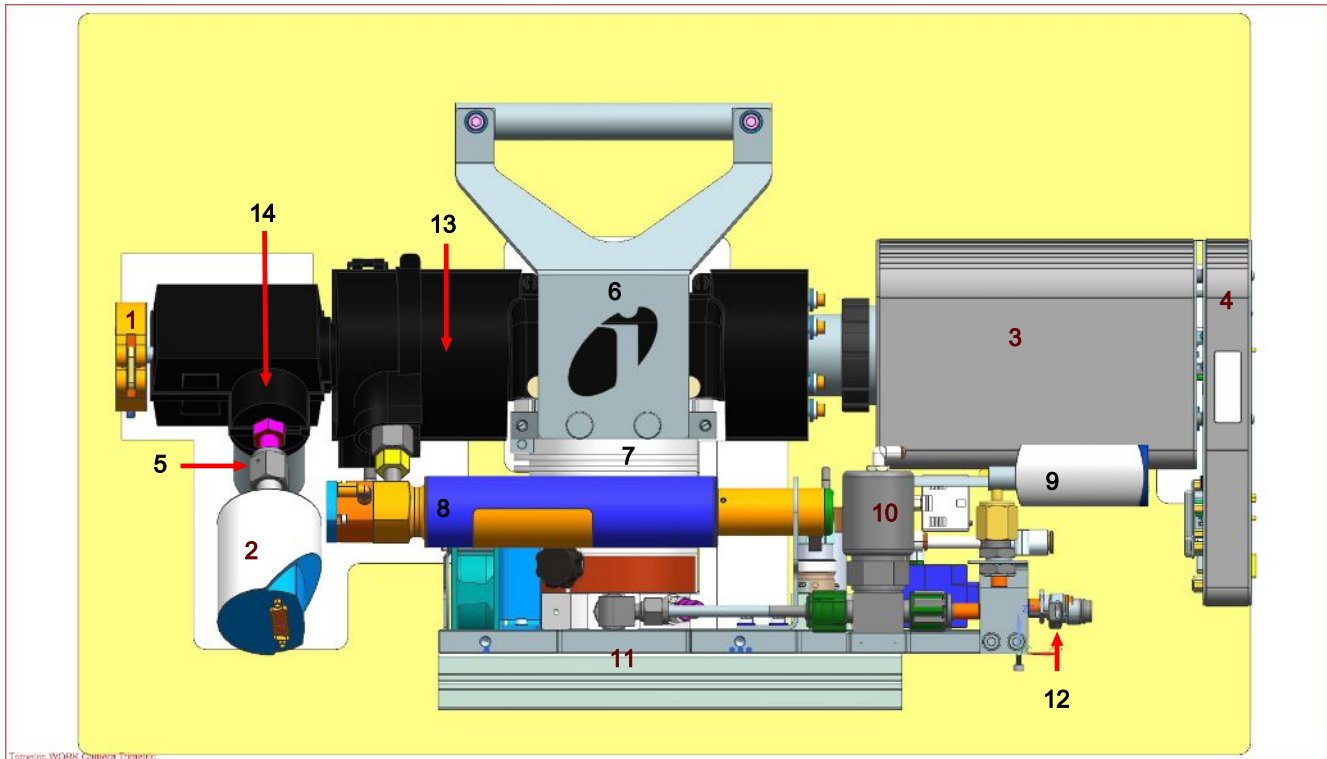
**12** Connect to Transpector APX ALD.

To change the IP address back to the default settings, follow steps 1 through 6 and reset the properties to their original settings.

# 10 How the System Works

## 10.1 Components

An example of a fully configured Transpector APX ALD corrosive pumping system is shown below.



|    |                                             |
|----|---------------------------------------------|
| 1  | Process connection                          |
| 2  | Process gauge                               |
| 3  | Electronics box                             |
| 4  | Vacuum System Interface (VSI)               |
| 5  | ALD isolation valve                         |
| 6  | Sensor manifold and heater                  |
| 7  | Turbo molecular pump                        |
| 8  | Calibration reference                       |
| 9  | Foreline Pirani gauge                       |
| 10 | Foreline isolation valve                    |
| 11 | Base plate and the rail                     |
| 12 | VCR port for the exhaust line               |
| 13 | System inlet assembly and heater            |
| 14 | System isolation valve and auxiliary heater |

## 10.2 Theory of Operation

Many gas analysis applications involve pressures too high for direct exposure to the quadrupole sensor. In that scenario, a pressure reduction system is required to reduce the inlet pressure and maintain the pressure at the quadrupole sensor at an operational level. With a pressure reduction system, a quadrupole sensor may be used for high pressure applications such as sputtering, chemical vapor deposition (CVD), etch, vacuum furnace analysis, and laser gas analysis.

The Transpector APX ALD pressure reduction system uses an orifice to reduce the partial pressure of the gas-mixture at the process side, typically by a fixed proportion, with minimum mass discrimination. An orifice, a small disk with a defined radius hole, acts as a conductance limitation. When both the volume and the high vacuum pump speed are constant, the orifice hole size determines the magnitude of the pressure drop from the process pressure to the pressure at the sensor for proper operation. Orifices are available in various sizes to cover various pressure ranges.



### **⚠ CAUTION**

**FabGuard displays the total pressure inside the closed ion source.**

Optimum performance is obtained when the total pressure display reads approximately  $2 \times 10^{-4}$  Torr ( $2.6 \times 10^{-4}$  mbar) measured in low energy mode (40 eV, 200  $\mu$ A) and in high energy mode (70eV, 2000  $\mu$ A).

## 10.3 Instrument Overview

### 10.3.1 Input/Output (Auxiliary I/O)

This section describes the available input and output (I/O) for Transpector APX ALD. Transpector APX ALD has two digital inputs, referred to as Remote Logic inputs, which default as emission control, two digital relay outputs (one of which reflects emission status by default), and two analog outputs. No analog input is available for Transpector APX ALD.

#### 10.3.1.1 Auxiliary I/O Connector

User I/O is provided through a DA15 female connector, labelled "USER I/O" on the VSI module.

A mating DA15 male connector is supplied in the ship kit for connecting to the Transpector APX ALD auxiliary I/O connections.

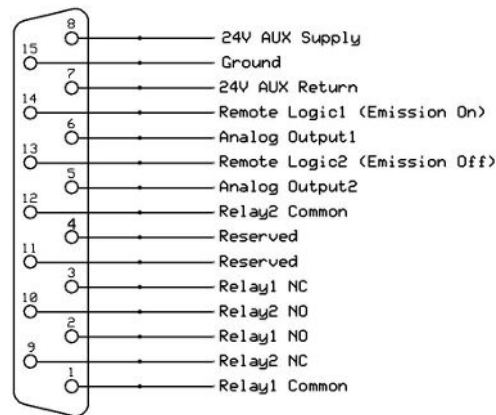
### 10.3.1.2 Two Digital Inputs (Remote Logic)

Remote Logic 1 and 2 are by default set to remotely control the emission status.

Remote Logic 1 turns on emission when transitioning from high to low. Remote Logic 2 acts as an emission interlock when in the low state, and will turn emission off when it enters the low state, if emission was on.

### 10.3.1.3 Two Relays

Two relays are available from AUX I/O. These relays may be used as digital outputs.

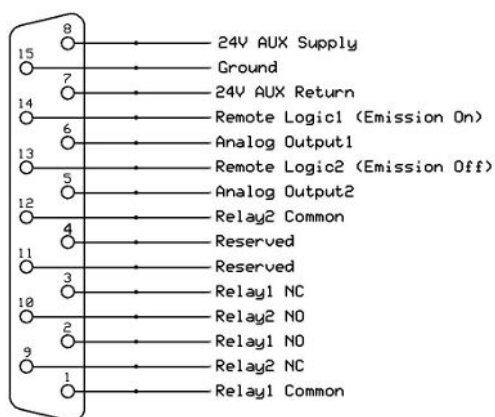


|                |                                                     |
|----------------|-----------------------------------------------------|
| Relay 1        | The relay is open = Pin 2 and pin 1 are connected.  |
| Relay 1        | The relay is closed = Pin 3 and pin 1 are connected |
| Contact rating | 24 V(DC) at 0.5 A                                   |
| Relay 2        | The relay is open = Pin10 and pin 1 are connected   |
| Relay 2        | The relay is closed = Pin 9 and pin 1 are connected |
| Contact rating | 24 V(DC) at 0.5A                                    |

### 10.3.1.4 Two Analog Outputs

Two analog outputs are available. The available analog output voltage range is from 0 V to +10 V and can be configured through control software.

|                 |                  |
|-----------------|------------------|
| Analog output 1 | pin 6 and pin 15 |
| Analog output 2 | pin 5 and pin 15 |



## 10.3.2 Ultra-High Vacuum System

The vacuum system provides low pressure to:

- Establish a sample flow from the process by pressure difference
- Provide low pressure for optimum operation of the sensor

A dry pumping system comprised of a turbomolecular pump and a foreline pump is used to minimize hydrocarbons in the residual gas background. The turbomolecular pump provides a high compression ratio between the high vacuum side and the foreline pump side for all gases, including hydrogen. Hydrogen is the major residual gas component in ultra-high vacuum. The high compression ratio for hydrogen is important for producing a low base pressure.

### 10.3.2.1 Foreline Subsystem

The foreline subsystem components include a flexible foreline hose of various lengths ( $\leq 10$  m [ $\leq 32$  ft.]), a foreline Pirani gauge, and a diaphragm foreline pump.

The foreline pump produces base pressures (when there is no gas flow) of 2 Torr (2.7 mbar), significantly less than the 12 Torr (16 mbar) needed for turbomolecular pump operation. The 2 Torr (2.7 mbar) operating pressure for the foreline is in the viscous gas flow regime such that the foreline does not require a large diameter. The inside diameter of the foreline is 6 mm (1/4 in.) which produces a 2 Torr (2.7 mbar) pressure drop across a 10 m (32 ft.) length of foreline at 20 sccm of gas flow. The foreline Pirani gauge can be used to troubleshoot pumping system problems and to verify that the turbo pump is being backed properly.

### 10.3.3 Heater(s) Subsystem

The heaters are zone-based cartridges with maximum temperature dependent upon the system configuration. The zones are divided into the Inlet Zone, the Manifold Zone, and the Auxiliary Zone. Plastic heater covers lined with insulation and an IR reflective material provide insulation.

The Transpector APX ALD VSI supplies power to the heaters.

Heater temperatures are defined in "Sensor Hardware Configuration" within FabGuard and each zone can be controlled interdependently. Zone states can be controlled manually or via recipe within FabGuard.



#### **WARNING**

**During or immediately after bakeout, the heating jacket and metal surfaces in the vicinity of the heating jacket are hot.**

These surfaces exceed 100°C at the maximum ambient operating temperature (35°C [95°F]), and can cause burns if touched.

### 10.3.4 Solenoid Valves

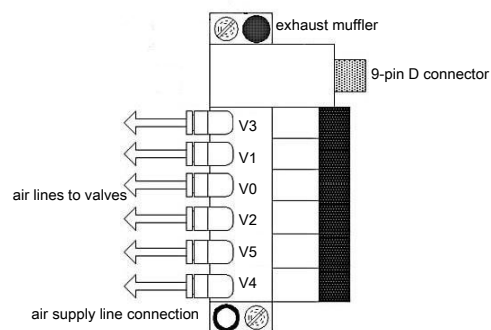
The solenoid-controlled valves are a group of valves joined together as one manifold assembly which is mounted to a bracket on the baseplate.

When solenoid valves are activated, compressed gas from the input gas supply (58–120 psi (4–8.3 bar) [400–690 kPa]) opens the appropriate valve. The recommended setting is 75–80 psi (5.17 to 5.52 bar) [517 kPa to 552 kPa]. The solenoid (pilot) valves are electrically operated. There are six solenoid valves on the valve block:

|    |                                                                                                                                                                                                                                                                                      |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| V0 | V0 is the foreline isolation valve. The valve is automatically opened and closed by the start/stop of the pumping system.                                                                                                                                                            |
| V2 | V2 is used to actuate ALD isolation valve. Typically, the Transpector is configured as single inlet, V2 only. If the process pressure is below the rated pressure of the orifice, the software application will open the ALD isolation valve for the system to sample process gases. |
| V5 | V5 is the valve on the calibration reference                                                                                                                                                                                                                                         |



Each solenoid has a red indicator that illuminates when the solenoid is activated.



### 10.3.5 Sensor and Electronics Module Subsystem

The sensor is a quadrupole partial pressure analyzer that analyzes gases by:

1. ionizing gas species
2. separating the ions by mass
3. measuring the quantity of ions at each mass

The masses, unique for each substance, allow the identification of the gas molecules from which the ions were created. The magnitudes of these signals are used to determine the partial pressures (amounts) of the respective gases.

The Transpector APX ALD electronics module mounts to the sensor and provides all of the requirements for operating the sensor, making the appropriate ion current measurements, communicating to a computer, and sending the resulting output to the computer.

The Transpector APX ALD VSI module contains all the cable connections to the various components of the Transpector APX ALD pumping system, including turbomolecular pump, gauges, and solenoid valves.

## 10.4 Application

The pumping and pressure reduction system reduces the pressure of process gas to allow proper operation at the ion source region. The pressure of  $2 \times 10^{-4}$  Torr ( $2.7 \times 10^{-4}$  mbar) at the ion source region is considered optimal for partial pressure measurements for the closed ion source (CIS). The general formula to calculate the flow rate of gas that produces the optimal pressure is described as below:

$$Q(\text{T-L/s}) = P_{\text{CIS}} S_{\text{CIS}}$$

$P_{\text{CIS}}$  = the pressure at the CIS ion source within the CPM manifold region

$S_{\text{CIS}}$  = the pumping speed of the closed ion source

$Q$  = throughput of the CIS ion source

This flow rate produced by process gas flowing through the process gas orifice is:

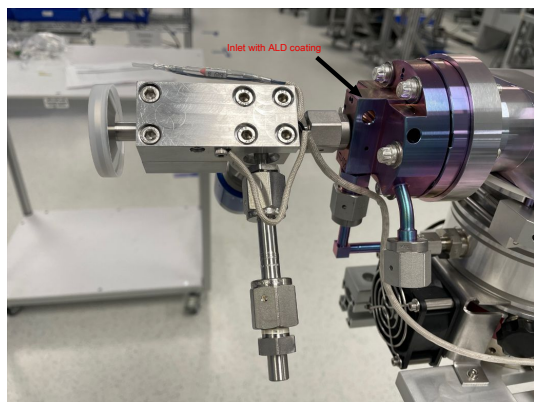
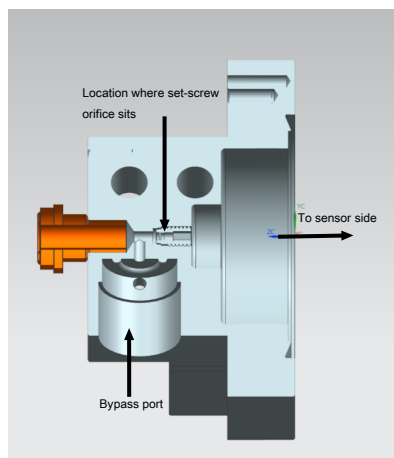
$$Q(\text{T-L/s}) = (P_{\text{Process}} - P_{\text{CIS}}) * C_{\text{Process Orifice}}$$

where the conductance  $C_{\text{Process Orifice}}$  determines the orifice diameters needed to produce this flow for each process pressure.

A selection of orifice diameters are available for reducing pressure for a multi-decade range of (maximum) process pressures ranging 0.001 – 100 Torr (1.3E-3 –133 mbar). For example, a 10 Torr (13 mbar) orifice has a 20 micron diameter hole to produce approximately  $2 \times 10^{-4}$  Torr (2.7E-4 mbar) at the CIS when the process has 10 Torr (13 mbar) of nitrogen. Since process pressures can vary within the operating range of the process, different pressure reductions may be needed. The Transpector APX ALD system has a variety of inlet orifices that allow pressure range sampling which typically covers measurement of the base pressure of the process chamber (for leak detection and base vacuum analysis), with a high conductance port and two orifices for process pressures.

## 10.5 Sample Inlet Systems and Examples of Use

### 10.5.1 Inlet System

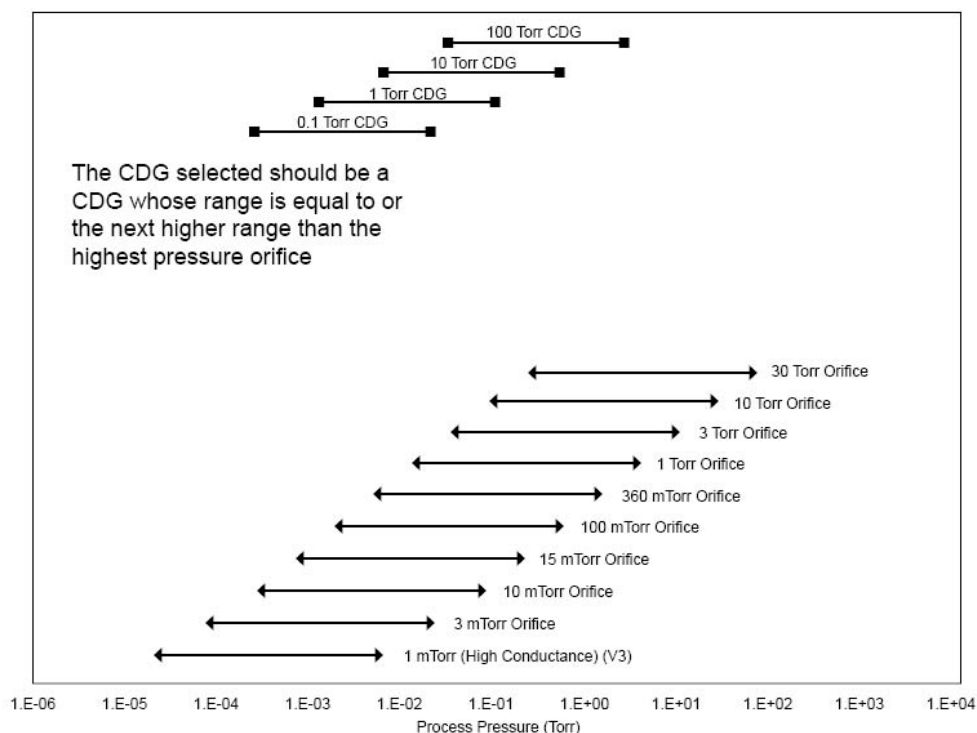


When both volume and high vacuum pump speed are constant, the orifice hole size determines the pressure at the sensor. Orifices are available in various sizes to cover several pressure ranges. The tables below show different orifices for low and high pressure range applications. The figure below shows pressure ranges for sampling which will assist in choosing the proper orifice for the application.

| Orifices                        | Part Number | Description                         |
|---------------------------------|-------------|-------------------------------------|
| 10 mTorr (1.3E-2 mbar) orifice  | 969-706-G6S | 10 mTorr orifice (750 micron) Gold  |
| 15 mTorr (2E-2 mbar) orifice    | 969-706-G8S | 15 mTorr orifice (350 micron) Gold  |
| 100 mTorr (1.3E-1 mbar) orifice | 969-706-G5S | 100 mTorr orifice (200 micron) Gold |
| 360 mTorr (4.8E-1 mbar) orifice | 969-706-G7S | 360 mTorr orifice (120 micron) Gold |
| 1 Torr (1.3 mbar) orifice       | 969-706-G4S | 1 Torr orifice (62 micron) Gold     |
| 3 Torr (4 mbar) orifice         | 969-706-G9S | 3 Torr orifice (35 micron) Gold     |
| 10 Torr (13 mbar) orifice       | 969-706-G3S | 10 Torr orifice (20 micron) Gold    |
| 30 Torr (40 mbar) orifice       | 969-706-G1S | 30 Torr orifice (10.5 micron) Gold  |

| Size of Orifices                | Part Number | Description                         |
|---------------------------------|-------------|-------------------------------------|
| 10 mTorr (1.3E-2 mbar) orifice  | 969-706-G6S | 10 mTorr orifice (750 micron) Gold  |
| 15 mTorr (2E-2 mbar) orifice    | 969-706-G8S | 15 mTorr orifice (350 micron) Gold  |
| 100 mTorr (1.3E-1 mbar) orifice | 969-706-G5S | 100 mTorr orifice (200 micron) Gold |
| 360 mTorr (4.8E-1 mbar) orifice | 969-706-G7S | 360 mTorr orifice (120 micron) Gold |
| 1 Torr (1.3 mbar) orifice       | 969-706-G4S | 1 Torr orifice (62 micron) Gold     |
| 3 Torr (4 mbar) orifice         | 969-706-G9S | 3 Torr orifice (35 micron) Gold     |
| 10 Torr (13 mbar) orifice       | 969-706-G3S | 10 Torr orifice (20 micron) Gold    |
| 30 Torr (40 mbar) orifice       | 969-706-G1S | 30 Torr orifice (10.5 micron) Gold  |



### 10.5.2 High Pressure Sampling: Orifice Bypass

When process pressures exceed 10 Torr (13 mbar), the process gas is dense enough that the gas molecules collide with each other more often than with the walls of the sampling system. In this transition or viscous flow regime, the time constant for detecting changes in process gas composition becomes dominated by the time it takes for the gas species that changes in the process to diffuse through the gas matrix and arrive at the sampling orifice. This diffusion time is proportional to the process pressure and the square of the distance from the process to orifice. This sampling method effectively shortens the diffusion distance from process change to the sampling orifice by drawing a small quantity ( $8.5 \pm 1$  sccm) of the process gas through the sampling valve and bypass valve to the interstage port of the turbomolecular pump. When the process gas flows in this manner, the diffusion distance of the gas is reduced to about 2 cm (0.8 in.) and the response time for changes in the process gas is significantly reduced.

## 10.6 Advice and Tips

### 10.6.1 Achieving Good Base Pressure

The Transpector APX ALD vacuum manifold must be baked out after initial installation or whenever the RGA sensor is exposed to air. After an eight hour bakeout and cool down, the base pressure must be less than  $5\text{E-}7$  Torr ( $6.7\text{E-}7$  mbar) at 40 eV, 200  $\mu\text{A}$ . If not, examine the background mass spectrum to look for the largest peak. If the spectrum is dominated by mass 18, continued bakeout is required to reduce water vapor.

### 10.6.2 Avoiding Trapped Gas when Sampling Valves are Closed

When V2 is closed, the sampled process pressure is trapped between V2 and the orifice installed at V2. This gas pumps out in a few minutes. It is best to keep V2 open until the process pressure is evacuated.



#### CAUTION

**Close the sampling valves when finished with measurements to avoid pressure bursts to the RGA if the process is vented.**



Transpector APX ALD turns off emission and the electron multiplier and closes all sampling valves when a pressure burst occurs.

# 11 Theory and Application Guide

## 11.1 Theory of Operation

A representative process gas sample is introduced into the ionization region of a closed ion source (CIS). The ions generated are focused into the linear quadrupole for separation by mass to charge ratio. The sampling and flow of the gas sample is accomplished by successive reduction of pressure from the process to the turbomolecular pump through fixed geometry pump-in channels.

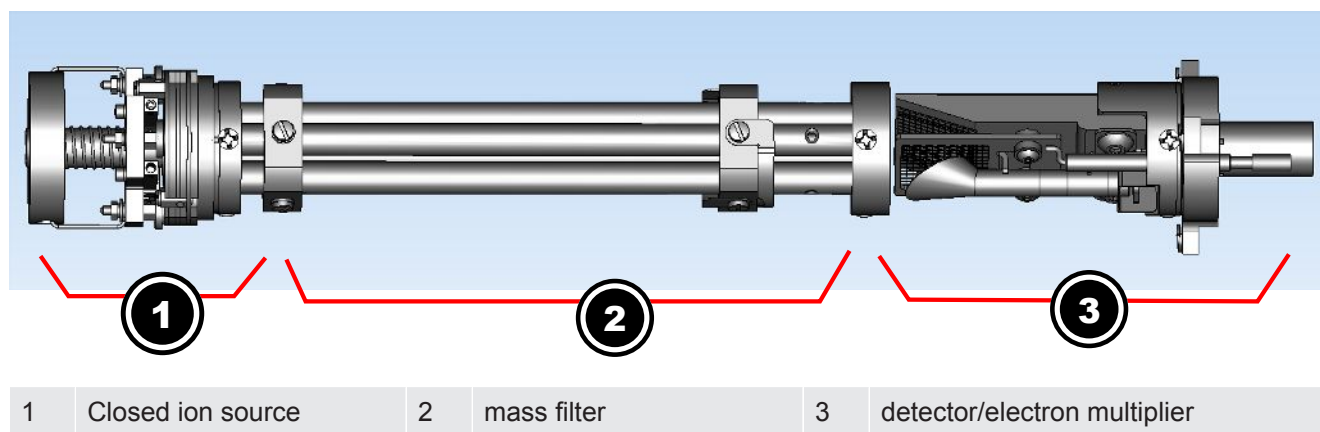
Transpector APX ALD detects levels of impurities in process gases that are significantly lower (at sub-ppm levels) for many components, than those that are detected by open-ion source RGA analyzers.

## 11.2 Sensors

The three main components of the Transpector APX ALD sensor are:

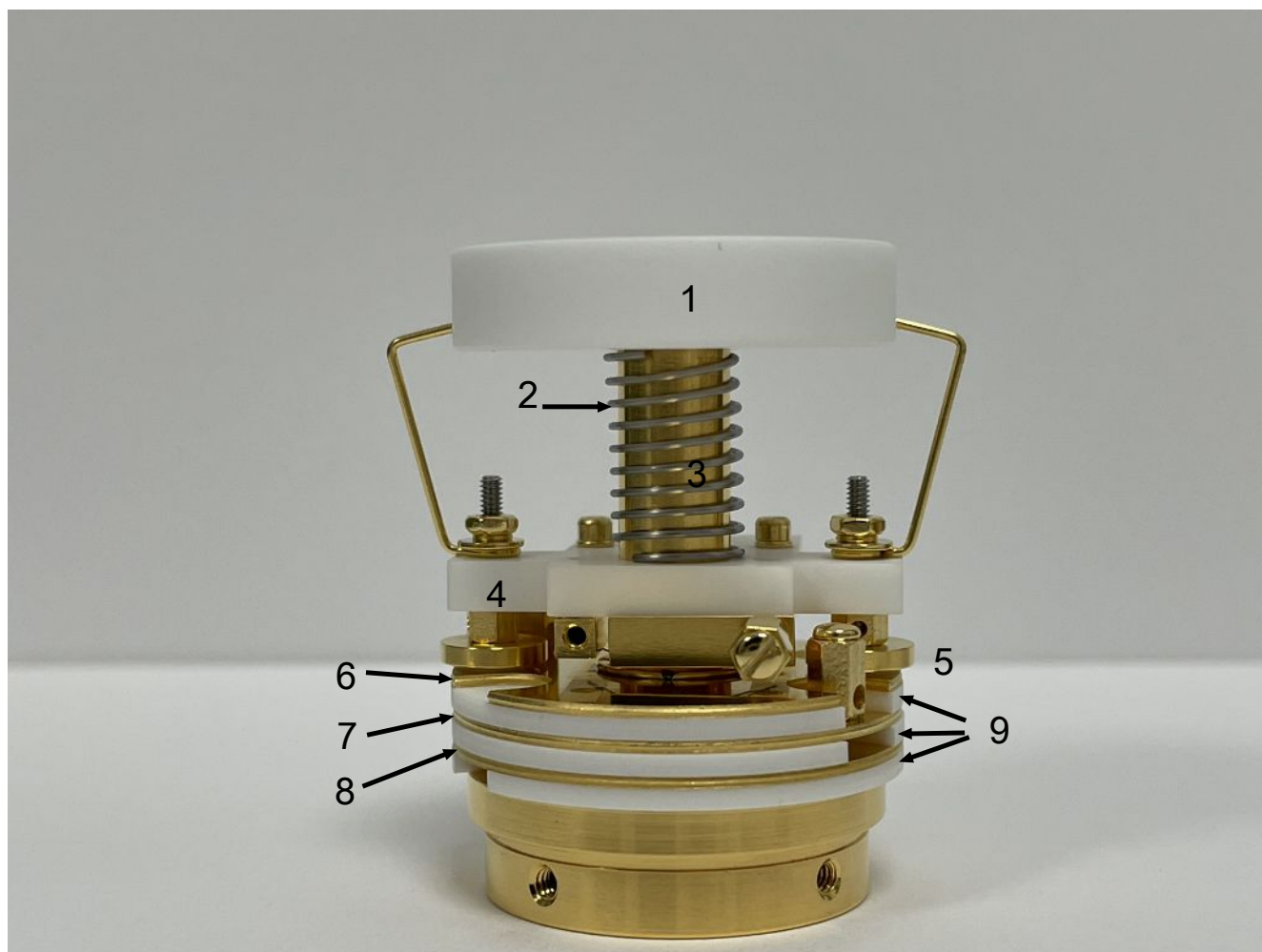
- Ion source (ionizer)
- Quadrupole mass filter
- Detector/electron multiplier

These components are mounted on an electrical feedthrough flange bolted to the vacuum manifold. The sensor works only in a high-vacuum environment because the ions, once created, must not collide with other gas molecules as they move through the sensor.



### 11.2.1 Closed Ion Source

A closed ion source is the chosen ion source type for most applications above 20 mTorr (2.7E-2 mbar).



|   |                |   |                      |   |                |
|---|----------------|---|----------------------|---|----------------|
| 1 | Sealing disk   | 2 | Spring               | 3 | Anode cylinder |
| 4 | Filament block | 5 | Shield washer        | 6 | Anode plate    |
| 7 | Focus plates   | 8 | Total pressure plate | 9 | Insulator ring |

Inside the closed ion source, a heated filament emits electrons which bombard the incoming gas molecules and give them an electrical charge. Transpector APX ALD detects only positive ions. Once a molecule is charged (ionized), electric fields can be used to manipulate the molecule.

The default filament is made of tungsten. Tungsten offers the best resistance to aggressive gases, particularly those containing fluorine and chlorine. A yttria coated iridium filament can be used in oxygen or water vapor heavy environments. Such environments would otherwise quickly oxidize a tungsten filament.



#### **⚠ CAUTION**

**Filaments can be damaged when operated at high pressures or environments with incompatible chemistry.**

The term emission current refers to the stream of electrons emitted by the filament. Emission current is controlled by the temperature of the filament.

The filament is centered over a hole in the anode cylinder. The potential (voltage) on the anode is positive with respect to the filament. The electron repeller, a flat plate, is located behind the filament and is electrically connected to the negative side of the filament. The potential difference between the filament and the anode determines the kinetic energy (electron energy) of the emitted electrons. The electron energy determines how gas molecules will ionize when struck by electrons.

Electron energy can range from 70 eV down to 10 eV. Operation below 70 eV is restricted to emission currents of no greater than 200  $\mu\text{A}$ . At 70 eV or above, an emission current of 2 mA will maximize sensitivity for background monitoring and leak checking.

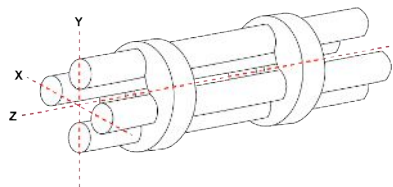
The ions formed within the ionization region are focused by the potential on the focus lens and formed into an ion beam. (The focus lens is also called an extractor, since it extracts the ions from the region in which they are created.) The focus lens focuses the ion beam into the hole in the source exit lens. To attract positive ions, the focus lens is biased negatively with respect to the anode.

The potential on the source exit lens is negative with respect to the anode and the focus lens. The ion beam passes through the hole in the exit lens and is injected into the mass filter.

## 11.2.2 Quadrupole Mass Filter

Ions produced in the ion source are focused into the quadrupole mass filter. RF and DC potentials are applied to the quadrupole mass filter. Each ion has a unique mass-to-charge ratio. The ratio of RF to DC potentials applied to the quadrupole dictates which mass-to-charge ratio is allowed through the quadrupole. The mass filter will step through different RF-to-DC ratios as needed to filter each mass-to-charge ratio of interest.





The mass filter's four rods (hence the term quadrupole) are alternately charged to direct ions of specific masses down through the center, deflecting all larger and smaller masses (hence the term mass filter).

The mass filter consists of four parallel rods, or poles, in a square array. The rods, and the insulators in which they are mounted, form an extremely precise mechanical assembly. The distance between the center of the square array and the closest rod surface is known as the quadrupole radius,  $r_0$ . Ideally, the rod should have a hyperbolic shape (towards the center of the assembly) rather than a round shape. If the ratio of the round rod radius to  $r_0$  is equal to 1.148, the resulting electric field is a reasonably good approximation of the desired hyperbolic shape.

Opposite rods are electrically connected together. The ions are directed into the space between the poles, in a direction nominally parallel to the length of the rods. There the ions are separated according to their mass-to-charge ratios by the lateral forces resulting from the potentials applied to the poles.

The applied potentials consist of an RF component and a DC component. The RF potential on one set of rods is out of phase by  $180^\circ$  with respect to the RF potential on the other set of rods, but all are the same amplitude. For one pair of rods, the "X" pair, the DC potential is positive. For the other, the "Y" pair, the DC potential is of the same magnitude, but negative. The DC and RF potentials are referenced to a center voltage (pole zero).

The following equations summarize the potentials applied to the rods:

$$[1] X = V_{\cos}(2\pi ft) + U + PZ$$

$$[2] Y = V_{\cos}(2\pi ft + \pi) - U + PZ$$

$V$  = RF amplitude

$f$  = RF frequency

$t$  = time

$U$  = DC potential

$PZ$  = pole zero

The RF component removes the low-mass ions from the beam. Ions of sufficiently low mass have their motions remain in phase with the applied RF. These ions will gain energy from the field and oscillate with increasingly large amplitudes. Eventually, as they travel along the length of the rods, they will strike one of the rods and be neutralized. High mass ions are focused by the RF component to an area close to the quadrupole's long axis, the Z axis.

The DC component is superimposed on the RF to remove high mass ions from the beam. The DC field deflects the high mass ions toward the negative poles, opposing the focusing effects of the RF field. Eventually, these high mass ions strike the negative rods and are neutralized. By a suitable choice of DC-to-RF ratio, the mass filter can be made to discriminate against both high and low mass ions. The ion energy directed along the Z axis of the mass filter is dependent on the difference between the potential at which the ions were formed (the anode voltage) and the pole zero.

The ion energy is usually only slightly modified by the electric field (the fringing field) between the source exit aperture and the quadrupole. Imbalances in the amplitude of the two phases of RF applied to the rod pairs, and DC voltages are also applied, resulting in a further modification of the ion energy.

The mass of the ions passed by the filter is determined by the RF amplitude, the RF frequency, and the quadrupole radius. (See equation [6].)

$$[3] V = 14.438Mf^2(r_0)^2$$

V = peak-to-peak RF amplitude in Volts

M = mass of the ion in atomic mass unites (amu) per electron charge

f = RF frequency in megahertz

$r_0$  = quadrupole radius in centimeters

For example, a 200 amu singly-charged ion would pass through a quadrupole with nominal 6.35 mm (1/4 in.) diameter rods (an  $r_0$  of 0.277 cm), operating at 1.78 MHz, at a peak-to-peak RF amplitude of approximately 700 Volts.

The mass of ions transmitted (M) is directly proportional to the RF amplitude (provided f is constant). As the RF amplitude is increased, progressively higher mass ions will be made to oscillate in phase with the RF field and thus gain sufficient energy to strike the poles. The DC voltage must be increased to maintain the high mass rejection properties of the filter. A mass spectrum is generated by sweeping the RF amplitude along with the DC voltage.

The next section (Scanning Characteristics) discusses the variation in the efficiency of transmission of ions through the filter with mass. The zero blast discusses the behavior of the filter at very low masses where the applied voltages approach zero.

### 11.2.2.1 Scanning Characteristics

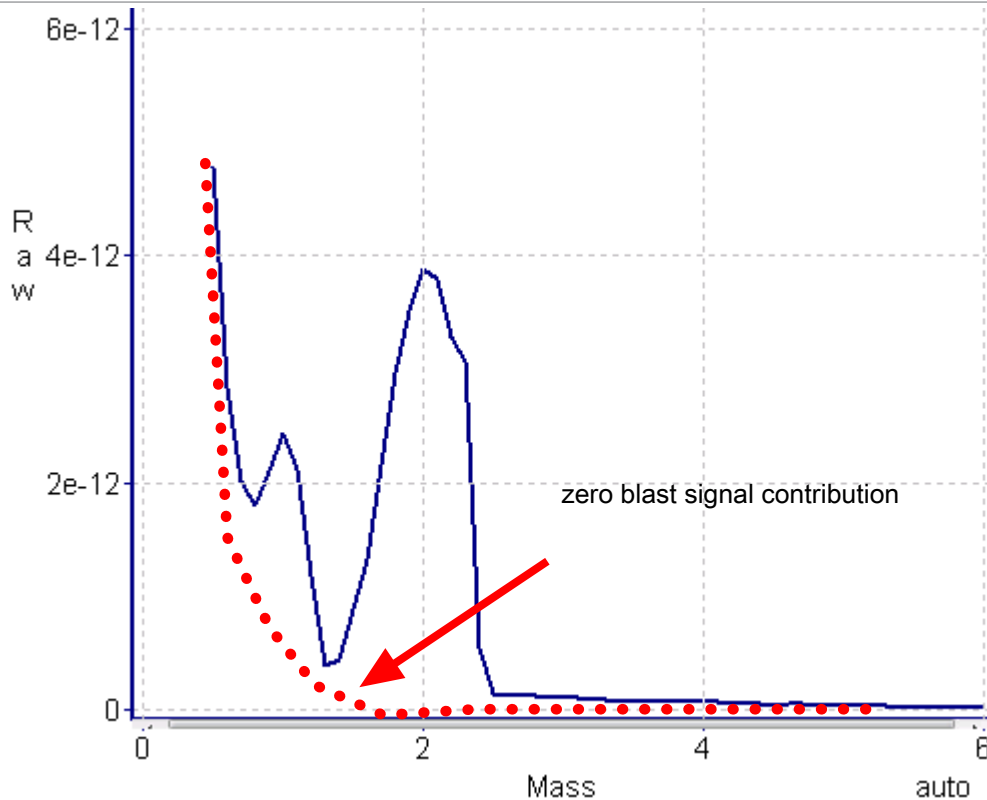
The quadrupole acts as a pass-band mass filter for a mixed beam of ions in normal operation, rejecting ions outside of the pass band and allowing ions with mass-to-charge ratios inside the pass band to travel to the detector. The selectivity of the mass filter is expressed in terms of resolution,  $R$ , which is numerically given by the ratio of the center mass-to-charge ratio,  $M$ , to the width,  $\Delta M$  (both unitless), of the pass band. Since the number of the ions passed by the filter falls off gradually as the edge of the pass band is approached, the width is defined at the point where the ion current falls to some specified fraction (usually  $1/2$  or  $1/10$ ) of the maximum value. The width of the pass band is determined by the DC-to-RF ratio.

The quadrupole can be designed so that  $R$  varies in any desired manner with  $M$ . However, keeping  $\Delta M$  constant ensures adequate separation of ions that are 1 MU apart. This mode of scanning is called Constant  $\Delta M$ . As a result,  $R$  is proportional to  $M$ , and therefore the efficiency with which ions of mass  $M$  are transmitted through the quadrupole decreases with  $M$ . Therefore, the sensitivity of the sensor decreases as  $M$  increases.

### 11.2.2.2 The Zero Blast

When the RGA scans over the very low end of the mass spectrum, the RF and DC voltages applied to the rods approach zero. The quadrupole then ceases to act as a filter and a large current of unseparated ions is detected, called the zero blast.

Zero blast will interfere with the observation of masses 1 and 2 in the higher pressure range of the RGA (for example,  $1\text{E-}6$  Torr to  $5\text{E-}4$  Torr [ $1.3\text{E-}6$  to  $6.7\text{E-}4$  mbar]) when significant quantities of higher-mass ions are present. The zero blast contribution to the mass 2 signal intensity can be between 5 ppm and 100 ppm depending on the mass range of the RGA.



### 11.2.2.3 The Ion Detector

The ion detector region of the sensor consists of the quadrupole exit lens, the electron multiplier and the detector itself. The quadrupole exit aperture is biased negatively with respect to the anode, focusing ions that have been transmitted through the quadrupole into the electron multiplier and detector.

#### 11.2.2.3.1 The Electron Multiplier (EM) Detector

The electron multiplier (EM) acts as an in situ pre-amplifier for improved sensitivity. Incoming ions are accelerated into the EM by a high negative voltage. When an ion strikes the surface of the EM, one or more secondary electrons are emitted. These electrons are accelerated to a second surface which is at a more positive potential, where additional electrons are generated.

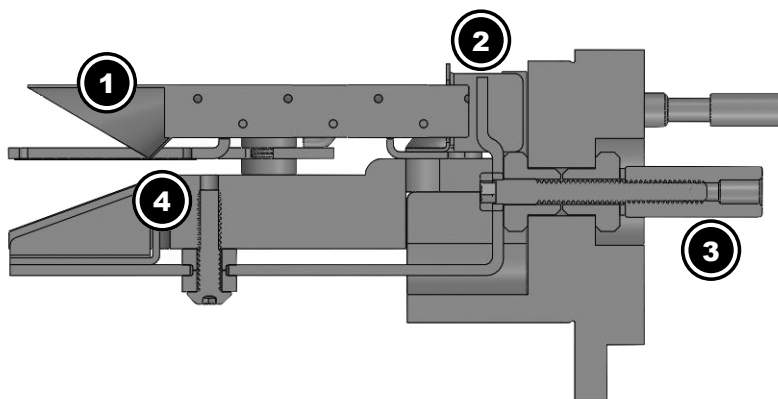
This process repeats itself until a pulse of electrons emerges from the output of the EM and is collected on a Faraday cup. The result is that as many as a million electrons or more can be produced by each incident ion. The current output from an EM detector is negative due to this pulse of electrons.

The ratio of the electron output current to the incident ion current is the EM gain. The gain primarily depends on the EM type, the voltage applied to the EM input, the voltage applied across the EM, the condition of the EM, and to a lesser extent the mass and chemical nature of the incident ion. In general, EM gain decreases as the

ion mass increases. The advantage of the EM detector sensor is its high sensitivity (as much as 500 A/Torr), making it possible to measure partial pressures as low as  $1 \times 10^{-15}$  Torr ( $1.3 \times 10^{-15}$  mbar) for a 100 amu sensor.

#### 11.2.2.3.2 The Continuous Dynode Electron Multiplier/Faraday Cup Detector

The continuous dynode electron multiplier/Faraday cup (CDEM/FC) detector amplifies the electron pulse, significantly increasing the analyzer's sensitivity.



|   |               |   |                    |
|---|---------------|---|--------------------|
| 1 | CDEM cone     | 2 | Electron collector |
| 3 | Signal output | 4 | Deflector shield   |

The CDEM/FC detector continuous dynode element is a special type of glass, rather than a copper-beryllium alloy that a discrete dynode EM might use. The advantage of the CDEM/FC detector over a discrete dynode EM detector is that CDEM/FC performance does not degrade when exposed to air and does not need to be stored under vacuum.

The maximum operating temperature for the CDEM/FC detector is 150°C.

The CDEM/FC detector is slightly slower to recover after exposure to excessive input or output currents. It may take longer for the gain to stabilize after the high voltage is changed.

The CDEM/FC detector is operated at high voltages between -0.6 and -2.0 kV. A new CDEM/FC detector will typically have a gain between 10 and 1,000 at -0.8 kV. The gain at -3.0 kV typically exceeds  $1 \times 10^6$ . The Transpector APX ALD default EM voltage is -0.8 kV.



#### **⚠ CAUTION**

**Do not operate the CDEM/FC detector at temperatures above 150°C. Permanent damage may result.**

**⚠ CAUTION**

**Avoid output currents in excess of  $1 \times 10^{-6}$  amps. Either decrease the high voltage or decrease the pressure.**

Use the minimum CDEM/FC detector voltage required to obtain the necessary peak amplitudes and/or signal-to-noise ratio. Operating at higher voltages than necessary will result in premature aging of the EM. As the CDEM/FC detector ages, the voltage needed to obtain a specific EM gain will increase.

Since EM performance depends on the condition of its interior surfaces, prevent hydrocarbon or other contamination:

- Make sure diffusion-pumped vacuum systems are properly trapped to reduce oil back-streaming.

EM gain reduction from these kinds of problems can range from 50% to more than 90%. The initial gain of the EM is generally high enough to accommodate some degradation and still be usable. With repeated instances of contamination, the EM will eventually require replacement.

**⚠ CAUTION**

**In addition to hydrocarbon contamination, an EM can be adversely affected by exposure to highly reactive chemicals.**

Avoid any substance that will either cause the deposition of a surface film on the EM or etch its surface. Avoid high levels of reactive fluorides, such as tungsten hexafluoride, hydrogen fluoride, and nitrogen trifluoride.

## 12 Operation

### 12.1 Single Pressure Inlet

The single pressure inlet provides necessary pressure reduction in order for the system to operate properly. The inlet includes a process pressure gauge and a calibration reference. The single pressure inlet offers several choices of a single orifice. The size of the orifice is dependent on the process pressure. The orifice matches with specific process pressure, from various applications such as high density plasma etch (HDP), TiN Deposition such as TDMAT, Tungsten CVD, or any other semiconductor process. Advantages include:

- Small vacuum path lengths for fast response time
- Minimum surface area
- Interchangeable orifices
- Multiple process connection options (KF40 and KF25)

The single pressure inlet includes a bypass line. The bypass connects to the inter-stage of the turbomolecular pump via a bypass tube which pulls gas from the process directly. The can cut the response time down from several minutes to less than ten seconds for a 100 Torr (133 mbar) process. The bypass inlet typically consumes approximately 17 sccms of process gas.

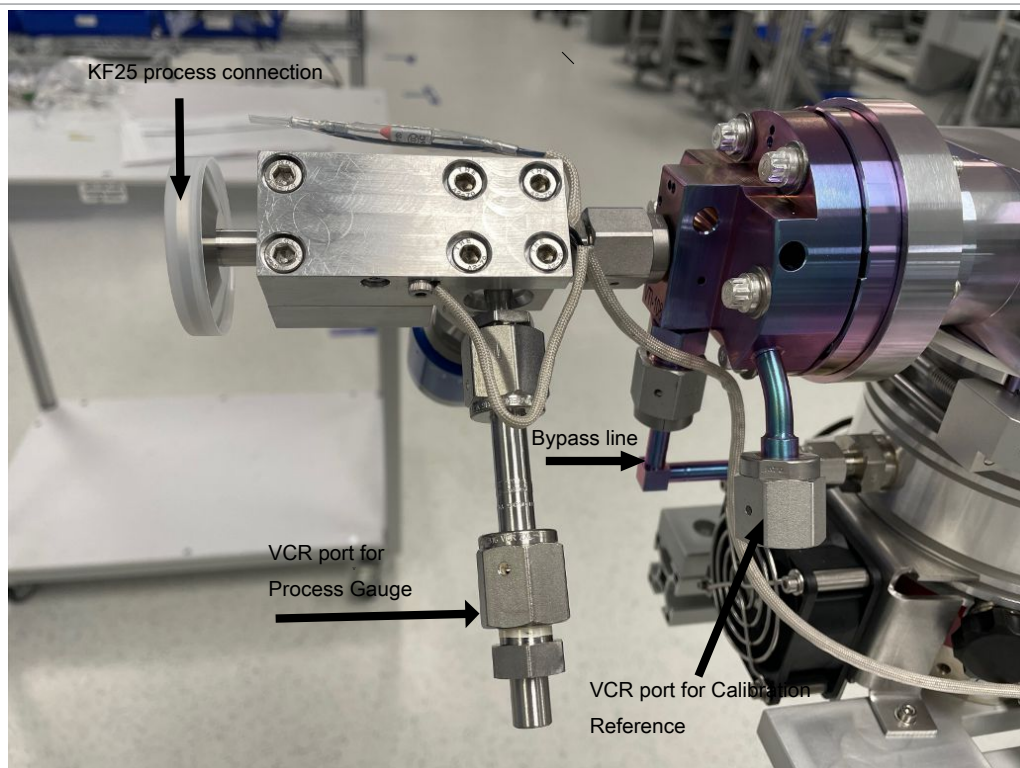


The orifice is installed in the single pressure inlet. Replacing the orifice requires removing the entire inlet; therefore, it is required that this be performed by INFICON service center trained technicians.



#### CAUTION

**The tool and the Transpector APX ALD must be vented before changing orifices, except when a tool isolation valve is installed.**



The standard calibration reference bottle has its own valve, and it can be operated through FabGuard application software. The calibration reference is located near the ion source. The calibration reference is used for mass tuning and as a sensitivity reference, providing:

- A means to tune the RGA.
- A reference for adjusting the EM voltage.
- A way to check whether the orifices are getting dirty or clogged.
- A reference for tracking the performance of the RGA.



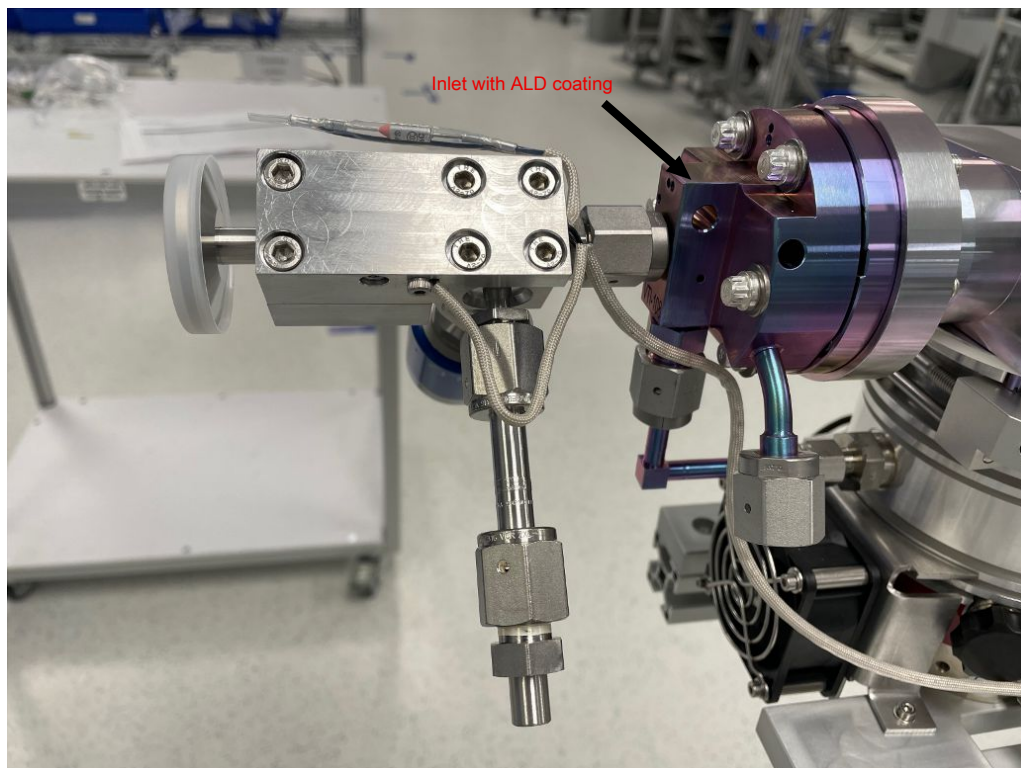
The Transpector APX ALD emission and EM are turned off prior to opening the calibration valve. This is due to trapped gas in the calibration reference.

- The process pressure gauge measures process pressure. It helps to prevent accidental or erroneous inlet valves from being opened at sub-optimal or unsafe pressures.

### 12.1.1 ALD Coating

Transpector APX ALD is designed for applications which use many harsh chemical gases like Halogens. To maximize the lifetime of the instrument and minimize the negative impact, some hardware of the instrument like the inlet will be coated with a defined thickness layer of Aluminum Oxide through Atomic Layer Deposition (ALD)

process. The ALD coating layers protect the instrument from harsh process gases which can otherwise clog inlet parts and coat or corrode the vacuum components of the instrument.



### 12.1.2 Calibration Option

A single source of gas mixture accomplishes two calibration functions:

- Mass scale calibration
- Partial pressure reference levels



Selection of the appropriate gas mixture components is dictated by the mass range desired.

The composition of the calibration reference option is shown in the table below. The method of delivery is a flow reference with a remote on/off valve (V5). The gas flow rate is calibrated at the factory and is kept small (typically  $1 \times 10^{-4}$  Torr-L/s [ $1.3 \times 10^{-4}$  mbar-L/s]) by a sintered leak. Flow through the leak element is viscous, therefore the gas composition in the reservoir is not altered by sampling. To ensure that no calibration mix enters the tool, the pumping system does not allow other valves to open with the calibration reference.

| Component<br>(Composition) | Calibration Masses |
|----------------------------|--------------------|
| H <sub>2</sub> (1%)        | 2                  |

| Component (Composition) | Calibration Masses |
|-------------------------|--------------------|
| He (1%)                 | 4                  |
| N <sub>2</sub> (1%)     | 28                 |
| Ar (balance)            | 36, 38, 40         |
| Kr (1%)                 | 86                 |
| Xe (1%)                 | 134                |



Refer to the software operating manual for more information regarding mass tuning. Results using FabGuard with this calibration mixture may be different than shown above due to the programming of the ionization probability and material factors.

### 12.1.3 Process Gauge

The Sky® capacitance diaphragm gauge (CDG) measures the pressure based on the elastic deformation of a ceramic diaphragm. The capacitance change caused by the deflection is converted into a linear output signal proportional to pressure.

The Sky CDG is resistant to high pressure surges. The Sky CDG type is selected based on process conditions. See the table below. Select a gauge based on maximum pressure orifice. The Sky CDG range must be equal to or the next higher range than the highest pressure orifice (typically V2).

| Process Range               | Part Number | Description                              |
|-----------------------------|-------------|------------------------------------------|
| 1 Torr (1.3 mbar) range     | 969-823-G1S | 1 Torr Sky CDG, Female VCR Connection    |
| 10 Torr (13 mbar) range     | 969-824-G1S | 10 Torr Sky CDG, Female VCR Connection   |
| 100 Torr (133 mbar) range   | 969-825-G1S | 100 Torr Sky CDG, Female VCR Connection  |
| 1000 Torr (1330 mbar) range | 969-826-G1S | 1000 Torr Sky CDG, Female VCR Connection |

## 12.2 Heaters

The Electronics module firmware interlocks the manifold and inlet heaters to the turbo pump being at normal speed. The auxiliary heater does not have this interlock. The manifold heater and inlet heater operates when the turbo pump is at normal speed (90,000 RPM). The temperature set point (Celsius) of manifold heater, inlet heater and auxiliary heater is programmable through FabGuard application software.

For proper operation of the heaters and to avoid burn hazard, the heater cover must be installed prior to operation.

## 12.3 Pumping System

The pumping system is preconfigured at the factory. The pumping system can be reconfigured with a different:

- Foreline pump, either system controlled or customer supplied
- Turbomolecular pump, either standard or corrosion resistance
- Inlet arrangement, the type of inlet and/or orifices

### 12.3.1 Foreline Pump

The system controlled foreline pump configuration is selected when there is an INFICON supplied foreline pump. If a third party pump is used to back other vacuum equipment, a check valve should be used to temporarily isolate Transpector APX ALD from any short (<10 seconds) pressure bursts that would damage Transpector APX ALD.



#### CAUTION

**A third party pump must supply a continuous foreline pressure below 12 Torr (16 mbar).**

### 12.3.2 Foreline Pirani Gauge

A Pirani gauge mounted to the Transpector APX ALD foreline monitors the pressure in the foreline. In the event of a pumping system malfunction, the foreline Pirani gauge will indicate a pressure >12 Torr (16 mbar) and shut down the system. For optimal pumping system performance, the foreline pressure should be <2.25 Torr (3 mbar).

### 12.3.3 Turbomolecular Pump

There are two types of pumping systems: standard (non-corrosive) and corrosive. The same standard turbomolecular pump is used in both applications.

The corrosive pump configuration is selected for applications, in which corrosive gases are being sampled. As configured at the factory, the nitrogen purge valve opens when the Transpector APX ALD turbomolecular pump is operating. The nitrogen purge valve can be configured in Fabguard software to remain closed when the turbomolecular pump is turned on.

The corrosive pumping system provides purge gas flow through the bearing region of the turbomolecular pump to protect the bearings from corrosion and loss of bearing lubricant by evaporation. The regulator is preset at the factory to produce  $8.5 \pm 1$  sccm of nitrogen purge. By default, the purge valve opens when turbo is on. The purge valve can now be configured to be left closed.

**⚠ CAUTION**

**For the corrosive service turbomolecular pump (CVD/etch), nitrogen purge gas is required whenever the system is operational.**

**⚠ WARNING**

**The turbomolecular pump must be completely at rest and the electronics power supply must be disconnected before removing the turbomolecular pump connecting cable.**

### 12.3.3.1 Turbomolecular Pump Status

Pump rotational speed is the RPM at which the turbomolecular pump is operating. Full speed is 90,000 RPM.

**⚠ CAUTION**

**With the corrosive turbomolecular pumping system, a nitrogen purge valve with regulator is connected to the purge port of the pump.**

The nitrogen purge valve is configured at the factory to open when the corrosive turbomolecular pump is running. This protects the bearings from corrosive gas attack and evaporation of the bearing lubricant.

## 12.4 Nitrogen Purge Valve for the Pumping Systems

The nitrogen purge valve provides a continuous flow of dry nitrogen to the bearings of the turbomolecular pump. By default, the nitrogen purge valve opens when the turbomolecular pump is turned on, and closes when the pump is shut down.

The purge valve can be configured to be left closed, if necessary.

It is highly recommended to open the purge valve and supply a continuous flow of dry Nitrogen when the system is sampling corrosive gas for diluting the concentration of process gases.

## 12.5 Filament Control

### 12.5.1 Interlock

On pump down, emission automatically turns on 30 seconds after the turbomolecular pump reaches full speed (90,000 RPM). The emission automatically turns off if the pump controller determines the turbomolecular pump is no longer up to speed.

### 12.5.2 Total Pressure Calibration

To protect the filament, Transpector APX ALD has a factory-calibrated total pressure lens that measures the total pressure in the closed ion source. The filament turns off (within 50 ms) after the pressure in the ion source rises above the total pressure setpoint, typically 1E-3 Torr (1.3E-3 mbar) @ 40 eV 200  $\mu$ A for a closed ion source.

The total pressure reading is calibrated with the ionizer set at both the default low emission settings (200  $\mu$ A emission; 40 eV electron energy) and default high emission settings (2mA at 70eV). The default value for the over-pressure setpoint is 1 to 3 mTorr (1.3E-3 to 4E-3 mbar).

When sampling at process pressures, running at high emission will result in poor linearity if the over-pressure does not trip. If 70 eV is desired for monitoring process gas, in FabGuard enter **Sensor Configuration** and change the electron energy to 70 eV, leaving the emission current at 200  $\mu$ A.

Re-calibration requires calculation of the pressure in the CIS when the process gas is introduced at a known pressure. The relationship is:

$$P_{CIS} = C_{Orifice} P_{Process} / C_{CIS} [1]$$

The table below lists the values for the exit conductance for CIS and for different orifices used in Transpector APX ALD sampling systems. Equation [1] can be used to infer the target gas pressure in the CIS that produces the total pressure measurement. Using the process gas pressure (measured by the CDG or other gauge) and the conductance of the orifice in use, the  $P_{CIS}$  value can be calculated to use the automatic Total Pressure Calibration option in FabGuard software.

| Orifice Designation     | Nominal Orifice Diameter (microns) | Conductance (L/s) | PCIS (Torr) [@ Design $P_{Process}$ ] |
|-------------------------|------------------------------------|-------------------|---------------------------------------|
| CVD-CIS Exit            | N/A                                | 1.0               | N/A                                   |
| 10 mTorr (1.3E-2 mbar)  | 675                                | 3.9E-2            | 3.9E-4                                |
| 100 mTorr (1.3E-1 mbar) | 170                                | 2.8E-3            | 2.8E-4                                |

| Orifice Designation | Nominal Orifice Diameter (microns) | Conductance (L/s) | PCIS (Torr) [@ Design P <sub>Process</sub> ] |
|---------------------|------------------------------------|-------------------|----------------------------------------------|
| 1 Torr (1.3 mbar)   | 55                                 | 2.7E-4            | 2.7E-4                                       |
| 3 Torr (4 mbar)     | 31                                 | 8.6E-5            | 2.6E-4                                       |
| 6 Torr (8 mbar)     | 22                                 | 4.4E-5            | 2.6E-4                                       |
| 10 Torr (13 mbar)   | 18                                 | 2.8E-5            | 2.8E-4                                       |

### 12.5.3 Filament Lifetime

Tungsten filament material is used in corrosive applications. The melting point of tungsten is 3410°C (6170°F); its boiling point is 5660°C (10220°F). At normal operating temperatures (approximately 2200°C [4000°F]), tungsten vapor pressure is approximately 1E-7 Torr (1.3E-7 mbar), which normally results in a reasonable lifetime. Various oxides of tungsten are known.

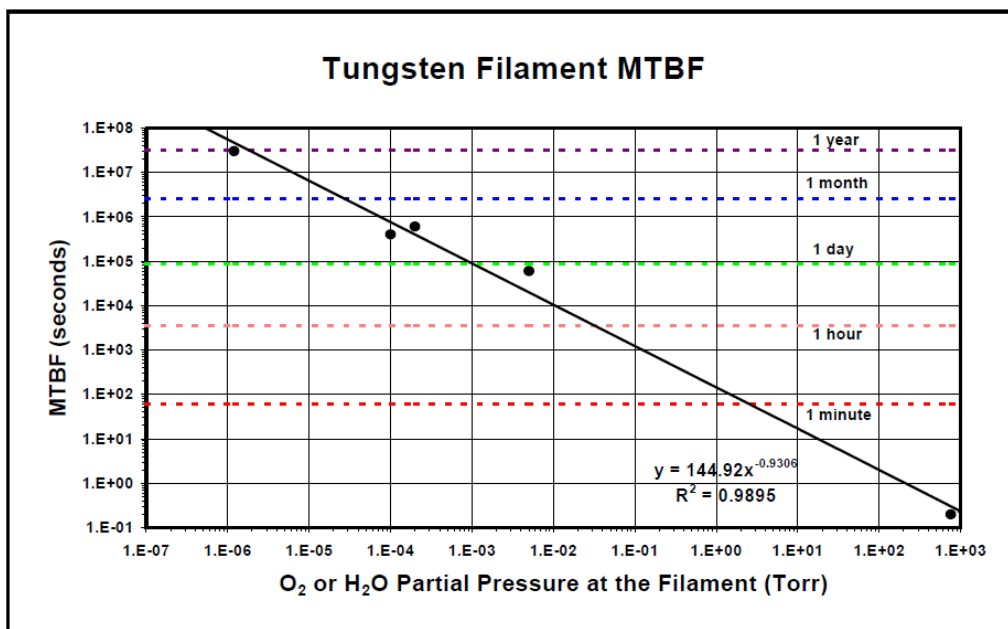
The lowest oxide, WO<sub>2</sub>, is brown in color and has a sublimation temperature of around 800°C (1470°F). The intermediate oxides, W<sub>2</sub>O<sub>5</sub> and W<sub>4</sub>O<sub>11</sub> are blue-violet in color and sublimes between 800°C and 900°C (1470°F and 1652°F).

The highest oxide, WO<sub>3</sub> is yellow in color and has a melting point of 1473°C (2680°F). No boiling point or sublimation temperature is reported, but presumably it is far more volatile than the pure metal itself.

At normal filament operating temperature, tungsten readily reacts with oxygen or water vapor to form oxides.

- If the oxygen (or water vapor) is very high, WO<sub>3</sub> is formed. This would be observed if an attempt had been made to turn on the filament in air at 760 Torr (1 bar).
- At lower oxygen (or water vapor) partial pressures, lower tungsten oxides are formed, giving rise to the blue color observed on the electron repeller. Since the tungsten oxides are far more volatile than the pure tungsten, when they form on the filament surface, they evaporate away, depositing on the nearest relatively cool surface.

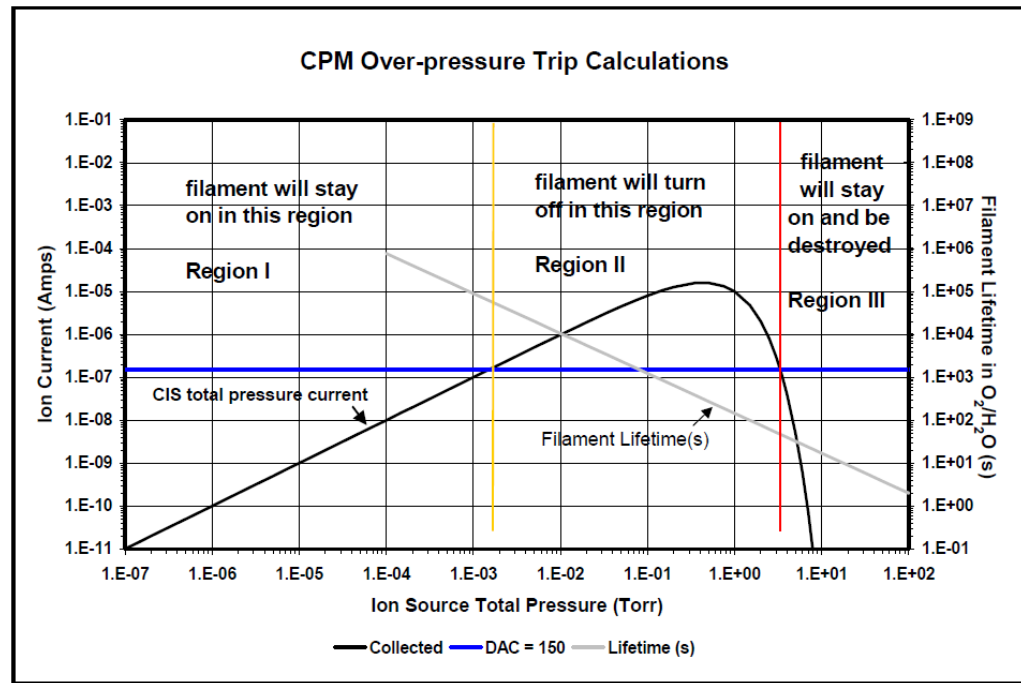
The figure below depicts a graph correlating tungsten filament mean time between failure (MTBF) in seconds with oxygen or water vapor partial pressure in Torr. The graph predicts a filament lifetime of approximately 200 seconds at 1 Torr (1.3 mbar), the maximum pressure at which Transpector APX ALD can maintain electron emission.



At 1 Torr (1.3 mbar) at the filament, the pressure inside the anode cylinder will be approximately five times higher (assuming the bulk of the gas load is entering the Transpector APX ALD manifold through the closed ion source).

At 5 Torr (6.7 mbar), the collisional mean-free-path for ions will be less than 0.01 mm (4E-4 in.). The distance from the ion creation region to the total pressure collector electrode is about 4 mm (0.16 in.), or approximately 400 mean-free-paths away. At this pressure, the scattering losses may sufficiently reduce the total pressure ion current so that it remains less than the over-pressure trip current. Under these conditions, the filament will stay on and react with the oxygen, producing relatively volatile tungsten oxides, until the filament diameter had been reduced to the point where the tension on the wire was sufficient to cause the wire to pull apart.

The figure below depicts a Transpector APX ALD over-pressure trip calculation. The total pressure current curve after 5E-1 is due to the pure collisional scattering. Without collisional scattering, it will be linear. The point where the CIS total pressure current and DAC line meet is called the over-pressure trip point. When the total pressure current exceeds the DAC line (Region II) the filament is turned off.

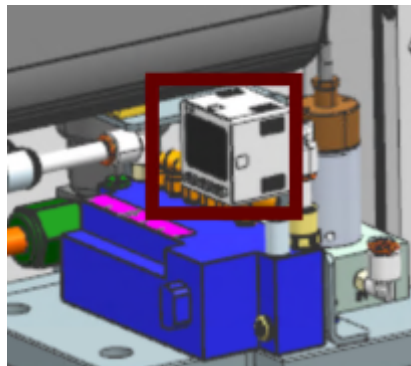


At 5 Torr (6.7 mbar) in Region III, there is no overpressure and no emission error, but the filament will last only hours. At 100 Torr (133 mbar), the filament will be destroyed instantly.

## 12.6 Pneumatic Digital Pressure Switch and Pressure Gauge

The pneumatic digital pressure switch and pressure gauge:

- Provides a visual display of the air (or nitrogen) pressure provided to the pneumatic block.
- Ensures a proper pressure for the Transpector APX ALD to function. If the pressure decreases below 58 psi (4 bar) [400 kPa] or exceeds 120 psi (8.3 bar) [827 kPa], the Transpector APX ALD system shuts itself down.



# 13 Maintenance

## 13.1 Introduction

The Transpector APX ALD sensor is subject to aging with normal use and some of its components will eventually require repair or replacement.



### **⚠ WARNING**

**Performing maintenance tasks on the Transpector APX ALD sensor should only be done by qualified personnel.**

INFICON provides complete maintenance service for Transpector APX ALD electronic modules, Transpector APX ALD sensors, and the pumping system.

## 13.2 Safety Considerations

If Transpector APX ALD is used in a manner not specified by INFICON, protection provided by the equipment may be impaired.

### 13.2.1 Toxic Material

The sensor does not contain any toxic material. However, if the sensor is used in an application wherein toxic material is used or generated, residue of the toxic material will likely be present on the surface of the sensor. Appropriate safety precautions must be taken when handling contaminated sensors in order to assure safety of maintenance personnel.

The electronics module is RoHS compliant.

### 13.2.2 Radiation

Transpector APX ALD gas analysis systems are not known to produce harmful radiation.

### 13.2.3 Electrical Voltages

Transpector APX ALD does not present electrical hazards when enclosed and grounded according to the specifications given in the installation instructions.



### **⚠ WARNING**

If the electronics module is operated while open, hazardous electrical voltages may be present. Such operation should only be performed by qualified service personnel.

## 13.3 General Instructions for All Maintenance Procedures



### **⚠ CAUTION**

Perform any servicing in a clean, well illuminated area.

Obey all cautions and warnings.

Wear clean, nylon, lint free lab gloves or finger cots.

Do not touch the vacuum side of the sensor with unprotected fingers.

Use clean tools for sensor disassembly and assembly.

## 13.4 Bakeout of Quadrupole

If the symptoms suggest that the sensor is contaminated, try first to restore normal performance by baking the sensor under a high vacuum (1E-5 Torr (1.3E-5 mbar) [1.3E-3 Pa] or lower) for several hours, preferably overnight. The table below shows the maximum bakeout temperatures.

If baking the sensor does not improve the sensor performance, it may be necessary to perform the tasks described in Filament Kit Replacement [► 81], and also in Ion Source Replacement [► 84].

If the procedures explained above do not solve the problem, contact INFICON.

|                                                   |         | While Operating | With Electronics Removed |
|---------------------------------------------------|---------|-----------------|--------------------------|
| Electron Multiplier<br>Faraday Cup<br>Combination | EM Mode | 150°C           | 300°C                    |
|                                                   | FC Mode | 200°C           | 300°C                    |



### **⚠ CAUTION**

When heating the sensor above 200°C, the electronics module must be removed from the sensor.

## 13.5 Maintenance Procedures

### 13.5.1 Tools Required

#### Tools for Replacing the Filament Kit

- Ohmmeter
- 3.2 mm nut driver
- 1.5 mm (1/16 in.) flat blade screwdriver
- 0.9 mm (.035 in.) hex driver
- Non-metallic precision tweezers

#### Tools for Replacing the Ion Source

- Ohmmeter
- 1.5 mm (1/16 in.) flat blade screwdriver
- 0.9 mm (.035 in.) hex driver
- #1 Phillips head screwdriver
- Non-metallic precision tweezers

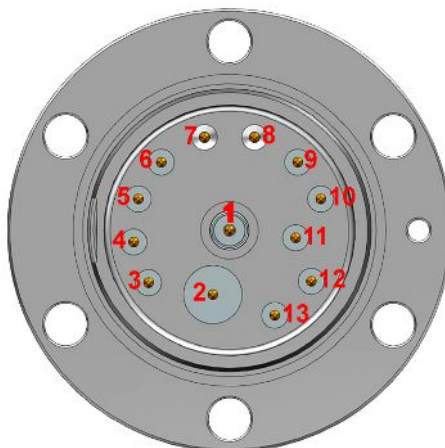
#### Tools for Replacing the Electron Multiplier

- 1.5 mm (1/16 in.) flat blade screwdriver
- #1 Phillips head screwdriver
- 1.5 mm x 50 mm hex driver
- 2.0 mm x 75 mm hex driver
- Non-metallic precision tweezers

### 13.5.2 How to Determine if a Filament Replacement is Required

Follow these steps to determine if a filament replacement is required.

- 1 Measure the resistance of each filament. This can be accomplished while the sensor is under vacuum by measuring the resistance between pins **3** and **10**. A failed filament will measure **open** while an intact filament will measure between 0.2 and 0.8Ω.





**Although the following measurements may measure below 30 MΩ with the filament assembly and ceramic shield in place, they must be above 30 MΩ when measured with the filament assembly and ceramic shield removed.**

- 2** Measure the resistance of each of the pins with respect to ground (pin **7** and **8**). These measurements must be above 30 MΩ.
- 3** Measure the resistance of each of the pins with respect to each other. All of these measurements must be above 30 MΩ, with the exception of measurements between each filament pin and the filament common pin if the filaments have not failed.

| Pin | Assignment      |
|-----|-----------------|
| 1   | PP              |
| 2   | EM HV           |
| 3   | Filament        |
| 4   | Reserved        |
| 5   | Anode           |
| 6   | RF-             |
| 7   | GND             |
| 8   | GND             |
| 9   | RF+             |
| 10  | Filament common |
| 11  | Reserved        |
| 12  | Focus           |
| 13  | TP              |

### 13.5.3 Filament Kit Replacement

Perform the following steps to replace the filament. Use non-metallic precision tweezers throughout replacement to aid in handling small parts.

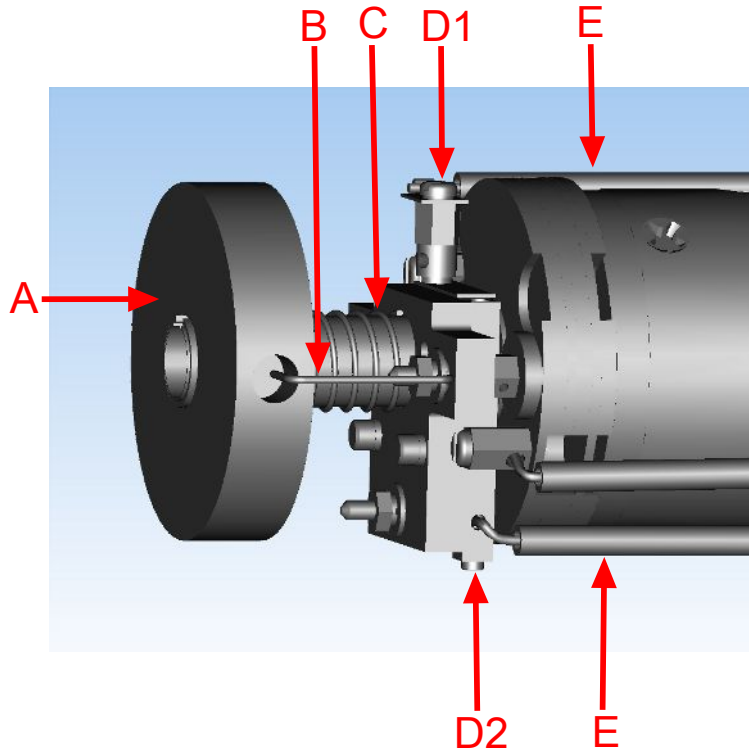


#### **⚠ CAUTION**

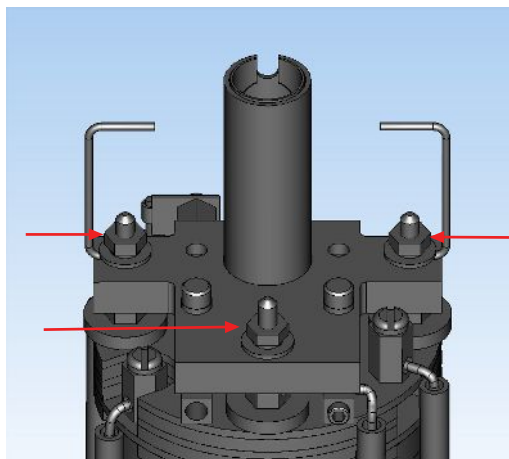
**Neither the filament assembly nor the ion source can be cleaned. When dirty, these components must be replaced.**

- ✓ Refer to Tools Required before continuing.

- 1 Remove the ceramic sealing disk (A) by carefully pulling the wire hold downs (B) away from the edges of the disk and pulling off the sealing disk.
- 2 Remove spring (C).
- 3 Remove the filament lead screw and washer (D1) using a 1.5 mm flat blade screwdriver, loosen the filament lead screw (D2) using a 0.9 mm hex driver and remove the filament leads (E) from the filament.

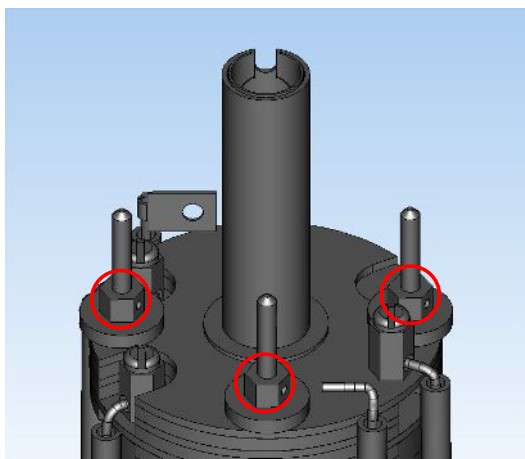


- 4 Remove three nuts and the washers holding the filament assembly in place using a 3.2 mm nut driver. Be careful; do not lose the two ceramic sealing disk wire hold downs.



- 5 Carefully remove the filament assembly.

- 6 Remove the three screws holding the filament assembly on the shipping fixture.



- 7 Carefully remove the new filament from its fixture and place it on the ion source posts.
- 8 Replace the three filament assembly nuts and washers. Be sure to install the wire hold downs.



### CAUTION

**To avoid cracking the ceramic plate, do not overtighten the three nuts.**

- 9 Reattach the filament leads and tighten the filament lead screws.
- 10 Reinstall the spring and the ceramic sealing disk.
- 11 Using an ohmmeter, check that the filament is not shorted to ground and that the filament shows a resistance of approximately 1Ω at the feedthrough.
- 12 Connect the RGA to FabGuard software and go to **Sensor Hardware Configuration**, view the **Lifetime** section, and select **Reset** for **Emission Filament (h)**.

| Parameter                                                | Value         |       |
|----------------------------------------------------------|---------------|-------|
| Sensitivity and EM calibration Type                      | Specific mass |       |
| Sensitivity mass (AMU)                                   | 28            |       |
| Sensitivity target (A/P)                                 | 0             |       |
| EM mass (AMU)                                            | 28            |       |
| EM target Gain                                           | 0             |       |
| EM target Signal (A)                                     | 0             |       |
| EM target Signal/Pressure (A/P)                          | 0             |       |
| EM calibration Gain (perform calibration to set)         | 0             |       |
| <b>Life Time</b>                                         |               |       |
| Power (h)<br>(time until next maintenance)               | 0 (277777)    | Reset |
| Emission Filament (h)<br>(time until next maintenance)   | 0 (277777)    | Reset |
| Electron Multiplier (h)<br>(time until next maintenance) | 0 (277777)    | Reset |
| <b>Plot</b>                                              |               |       |
| Units                                                    | Raw           |       |
| Tag Scan Subtract                                        | None          |       |
| Scan X axis type                                         | Linear        |       |
| Scan Y axis type                                         | Linear        |       |
| Trend X axis type                                        | Linear        |       |
| Trend Y axis type                                        | Linear        |       |

- 13 Reset the Emission Filament (h) to zero.



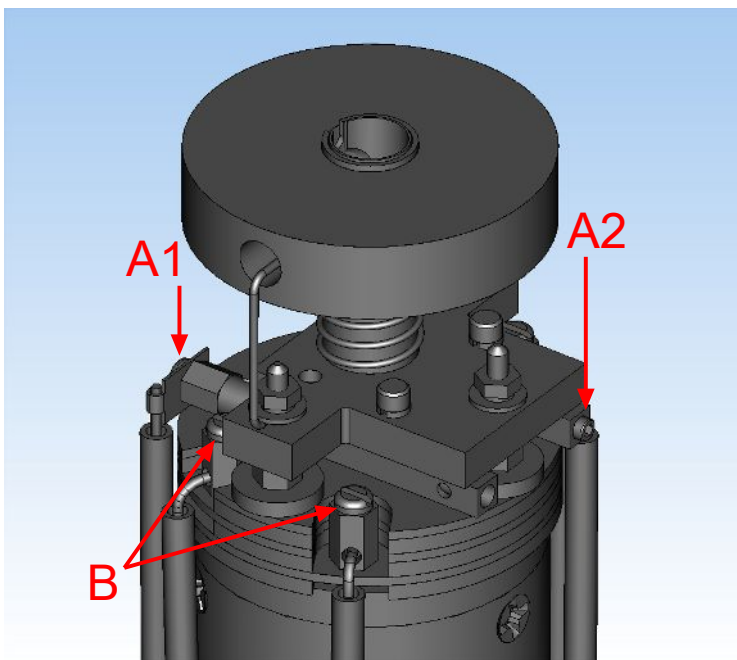
**It is required to perform sensor tuning, calibrating Faraday sensitivity, and calibrate sensitivity and EM gain before using the RGA.**

### 13.5.4 Ion Source Replacement

Proceed as follows to replace the ion source. Use non-metallic precision tweezers throughout replacement to aid in handling small parts.

✓ Refer to Tools Required before continuing.

- 1 Remove filament lead screw (A1) using a 1.5 mm flat blade screwdriver, loosen filament lead screw (A2) using a 0.9 mm hex driver, and loosen the three screws (B) using a 1.5 mm flat blade screwdriver.



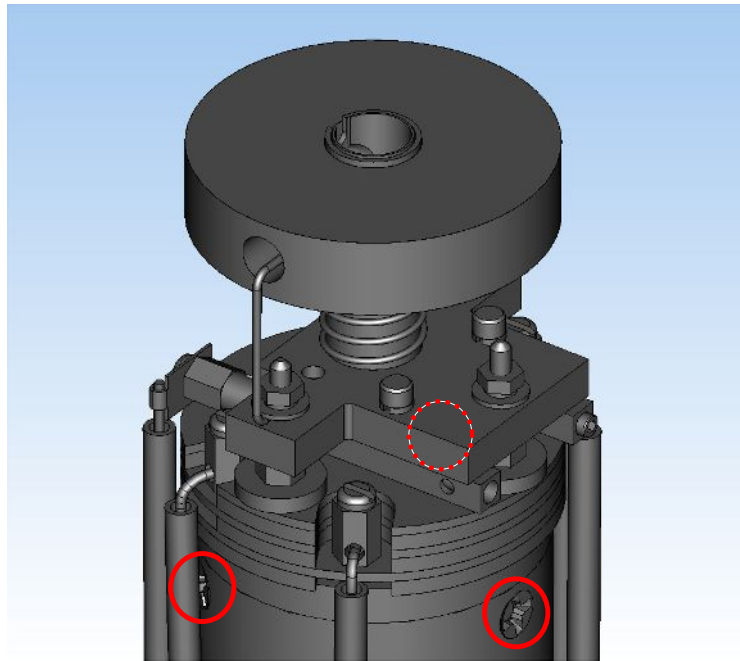
- 2 Pull the electrical leads away from the sensor.



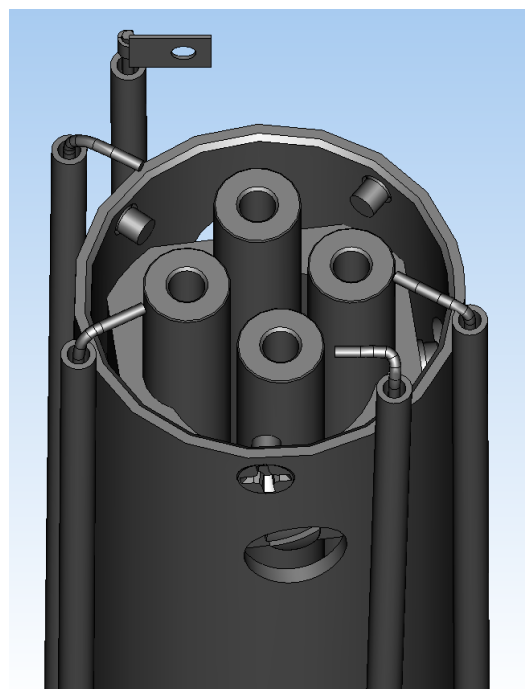
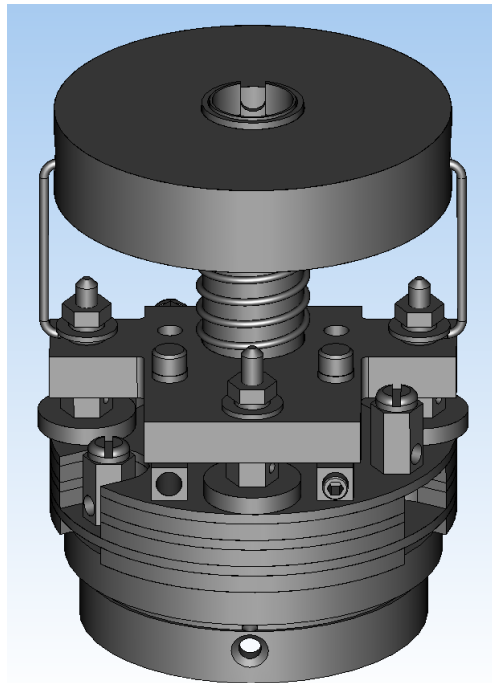
#### **⚠ CAUTION**

**Do not bend the leads.**

- 3 Remove the three ion source retaining screws (circled in red, one is hidden in the figure) around the bottom of the ion source assembly using a #1 Phillips head screwdriver. They hold the ion source onto the mass filter.



- 4 The ion source can now be removed by lifting it off the mass filter. Install a new ion source by reversing the above steps.



- 5 Using an ohmmeter, check:
- ⇒ That the filament is not shorted to ground or to any of the ion source plates.
  - ⇒ That the two filament leads show a filament resistance of approximately  $1\Omega$  at the feedthrough (approximately  $0.5\Omega$  at the lead connectors). See the image below for pin-out locations.
- 6 Connect the RGA to FabGuard software and go to **Sensor Hardware Configuration, Lifetime** section, and select **Reset** for **Emission Filament (h)**.

- 7 Reset the Emission Filament (h) to zero.



It is required to tune the mass-scale table, calibrate Faraday sensitivity, calibrate sensitivity and calibrate EM gain before using the RGA.



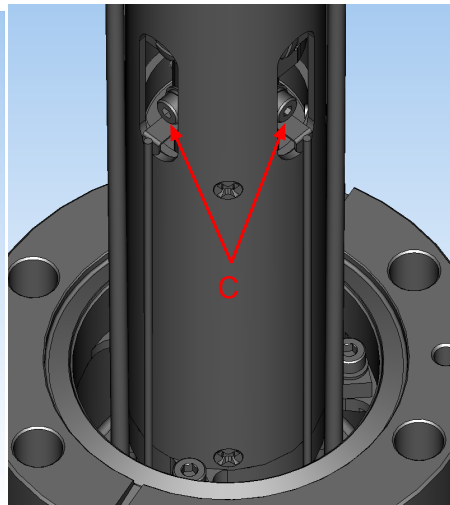
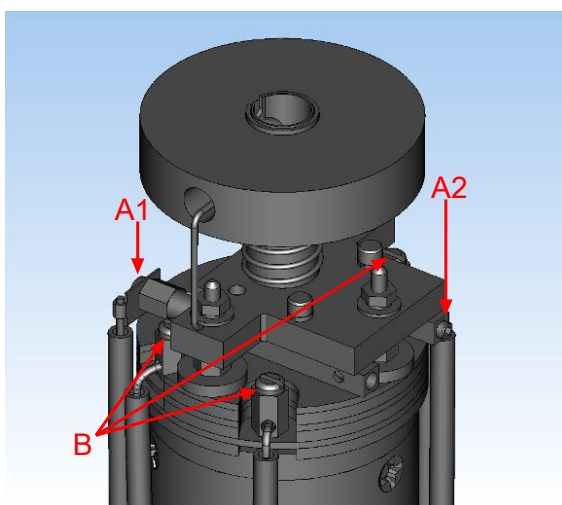
It is highly recommended to perform total pressure calibration, if possible, after replacing the ion source.

### 13.5.5 Electron Multiplier Replacement

The following steps should be performed to replace the electron multiplier. Use non-metallic precision tweezers throughout replacement to aid in handling small parts.

✓ Refer to Tools Required before continuing.

- 1 Remove filament lead screw (A1) using a 1.5 mm flat blade screwdriver, loosen the filament lead screw (A2) using a 0.9 mm hex driver, and loosen the three screws (B) using a 1.5 mm flat blade screwdriver. Using the 1.5 x 50 mm hex driver, unscrew the screws (C) that secure the two RF leads. Make sure to remove the lock washers as well. There are a total of seven leads that must be loosened.



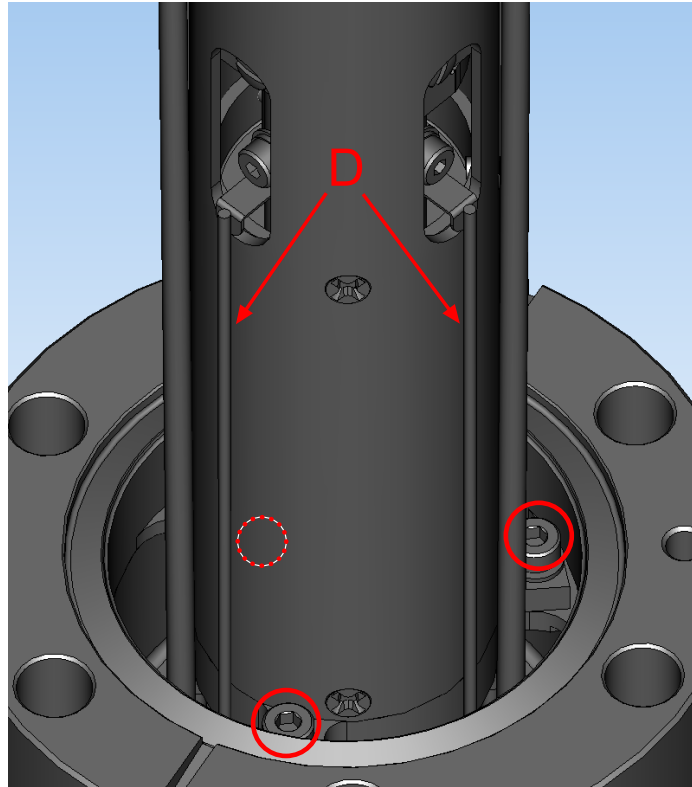
- 2 Gently pull the electrical leads away from the sensor.



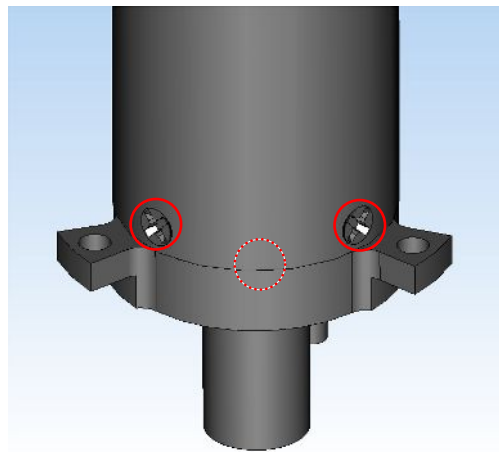
#### CAUTION

Do not bend the leads.

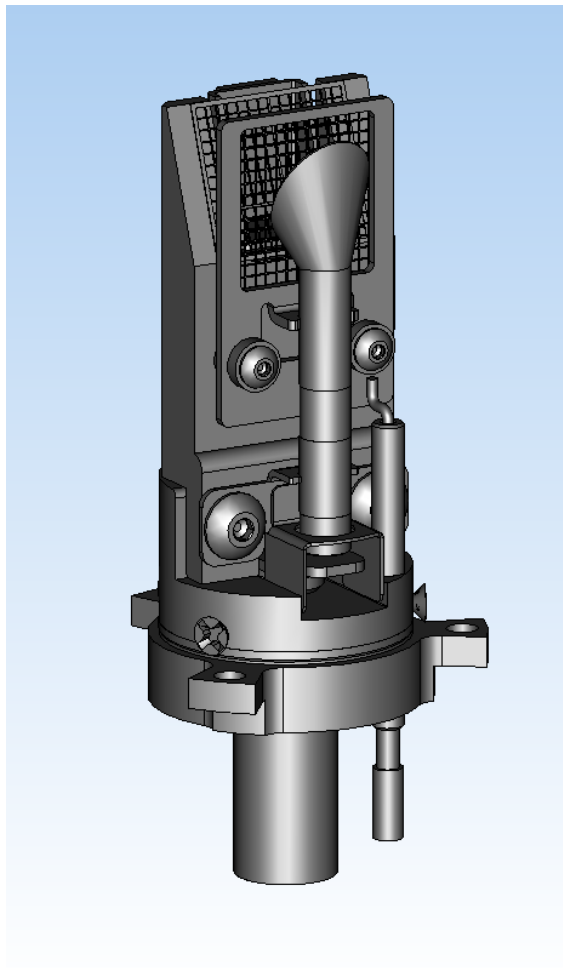
- 3 Using the 2.0 x 75 mm hex driver, unscrew three screws and three locking washers (circled in red, one is hidden in the figure) holding the sensor assembly to the feedthrough. Gently remove the sensor assembly from the feedthrough. It may be necessary to remove the RF Leads (D) using precision pliers.



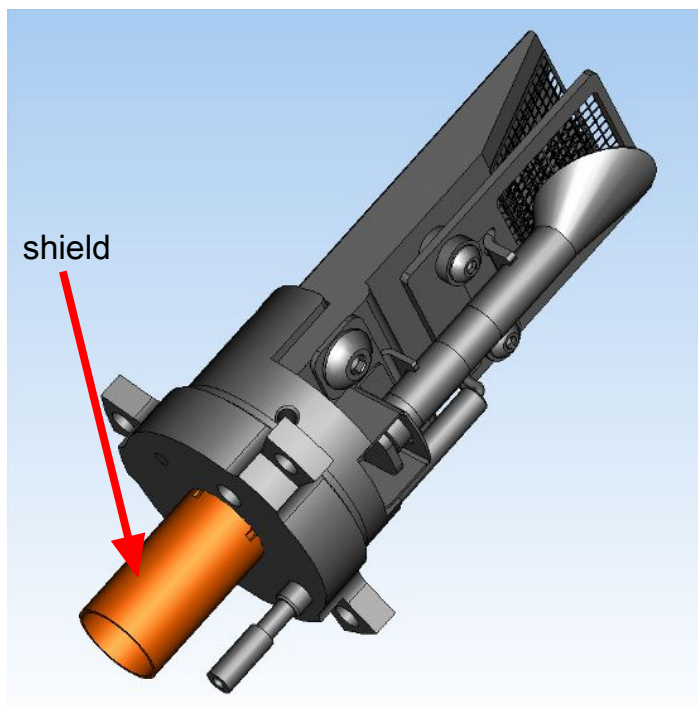
- 4 Using a #1 Phillips head screwdriver, remove three gold screws (H, one is hidden in the figure) holding the EM assembly inside of the sensor assembly.



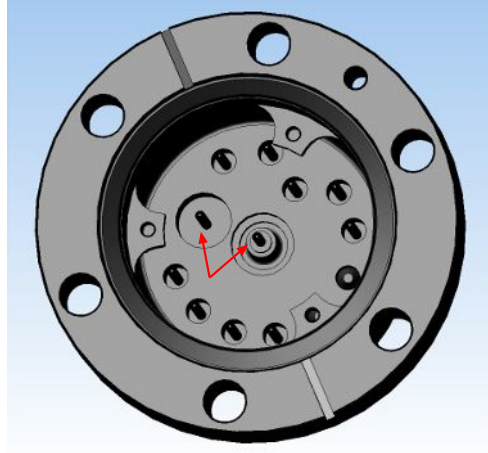
- 5 Gripping the bottom of the EM assembly, gently remove the EM assembly from the sensor assembly.



6 Remove the signal shield on the bottom of the old detector assembly.



- 7 Install the signal shield removed in step 6 onto the new electron multiplier assembly.
- 8 Inspect the feedthrough pins for any contacts that may have come loose from the detector and remove the contact from the feedthrough pin prior to installing the new detector.
- 9 Install the new electron multiplier assembly into the sensor can.
- 10 When installing the sensor back into the feedthrough, ensure that the two pins on the bottom of the detector align with the two pins on the feedthrough.



- 11 Reverse steps 1-4 to reassemble the Transpector APX ALD sensor.



**It is required to tune the mass-scale table, calibrate Faraday sensitivity, calibrate sensitivity and calibrate EM gain before using the RGA.**

## 13.5.6 Changing Diaphragms in the Foreline Pump

### 13.5.6.1 Replacement Interval

The foreline pump diaphragm disks, valve seals, valve disks, and O-rings must be replaced every 8000 hours of operation, when used in an inert environment. More frequent diaphragm replacement are required in less than optimal operating/process conditions.

## 14 Recommended Parts List

### 14.1 Ordering Information

To contact INFICON order services regarding Transpector APX ALD, please use the following contact information:

INFICON, Inc.

Two Technology Place

East Syracuse, NY 13057

USA

Tel: +315.434.1100

email: reachus@inficon.com

### 14.2 Sensors

The following spare sensors should be readily available.

| Part Number | Description                                                      |
|-------------|------------------------------------------------------------------|
| 961-M1MCS   | 100 AMU sensor with Y2O3/Ir filament                             |
| 969-1MLS    | 100 AMU sensor with Y2O3/Ir filament, coated/gold                |
| 961-M1MHS   | 100 AMU sensor with Y2O3/Ir filament & anode liner               |
| 969-1MNS    | 100 AMU sensor with Y2O3/Ir filament & anode liner, coated/gold  |
| 969-1MMS    | 100 AMU sensor with tungsten filament, coated/gold               |
| 961-M1MJS   | 100 AMU sensor with tungsten filament & anode liner              |
| 969-1MPS    | 100 AMU sensor with tungsten filament & anode liner, coated/gold |
| 961-M2MCS   | 200 AMU sensor with Y2O3/Ir filament                             |
| 969-2MLS    | 200 AMU sensor with Y2O3/Ir filament, coated/gold                |
| 961-M2MHS   | 200 AMU sensor with Y2O3/Ir filament & anode liner               |
| 969-2MNS    | 200 AMU sensor with Y2O3/Ir filament & anode liner, coated/gold  |
| 961-M2MDS   | 200 AMU sensor with tungsten filament                            |
| 969-2MMS    | 200 AMU sensor with tungsten filament, coated/gold               |
| 961-M2MJS   | 200 AMU sensor with tungsten filament & anode liner              |
| 969-2MPS    | 200 AMU sensor with tungsten filament & anode liner, coated/gold |
| 961-M3MCS   | 300 AMU sensor with Y2O3/Ir filament                             |
| 969-3MLS    | 300 AMU sensor with Y2O3/Ir filament, coated/gold                |
| 961-M3MH    | 300 AMU sensor with Y2O3/Ir filament & anode liner               |

|           |                                                                  |
|-----------|------------------------------------------------------------------|
| 969-3MNS  | 300 AMU sensor with Y2O3/Ir filament & anode liner, coated/gold  |
| 961-M3MDS | 300 AMU sensor with tungsten filament                            |
| 969-3MMS  | 300 AMU sensor with tungsten filament, coated/gold               |
| 961-M3MJS | 300 AMU sensor with tungsten filament & anode liner              |
| 969-3MPS  | 300 AMU sensor with tungsten filament & anode liner, coated/gold |

## 14.2.1 Consumable Parts

The following consumable parts should be readily available.

| Part Number | Description                                                                |
|-------------|----------------------------------------------------------------------------|
| 969-818-G1S | APX CIS tungsten filament kit                                              |
| 969-800-G1S | APX CIS tungsten filament kit, gold                                        |
| 969-818-G2S | APX CIS coated filament kit                                                |
| 969-800-G2S | APX CIS coated filament kit, gold                                          |
| 969-819-G1S | APX CIS tungsten ion source kit                                            |
| 969-801-G1S | APX CIS tungsten ion source kit                                            |
| 969-819-G2S | APX CIS tungsten coated ion source kit with anode liner                    |
| 969-801-G2S | APX CIS tungsten coated ion source kit with anode liner, gold              |
| 969-819-G3S | APX CIS coated ion source kit                                              |
| 969-801-G3S | APX CIS coated ion source kit, gold                                        |
| 969-819-G4S | APX CIS coated ion source kit with anode liner, gold                       |
| 969-801-G4S | APX CIS coated ion source kit with anode liner, gold                       |
| 915-724-G   | Package of three spare liners (used only with liner configured ion source) |
| 059-0828S   | Retained NI gasket                                                         |
| 059-0826S   | Unretained NI gasket                                                       |
| 961-707-G1  | Electron multiplier replacement kit                                        |

## 14.3 Electronic Boxes

The following electronic boxes should be readily available.

| Part Number | Description                     |
|-------------|---------------------------------|
| AP-A110S    | APX ALD 100 AMU electronics box |
| AP-A210S    | APX ALD 200 AMU electronics box |
| AP-A310S    | APX ALD 300 AMU electronics box |
| 969-210-G1S | Spare APX cable box assembly    |

## 14.4 Orifice Kits

The following spare parts should be readily available.

| Part Number  | Description                                         |
|--------------|-----------------------------------------------------|
| 969-706-G6S  | 10 mtorr HexBlock orifice (750 micron), gold        |
| 969-706-G8S  | 15 mtorr HexBlock orifice (350 micron), gold bypass |
| 969-706-G5S  | 100 mtorr HexBlock orifice (200 micron), gold       |
| 969-706-G7S  | 360 mtorr HexBlock orifice (95 micron), gold        |
| 969-706-G4S  | 1 Torr HexBlock orifice (62 micron), gold           |
| 969-706-G9S  | 3 Torr HexBlock orifice (35 micron), gold           |
| 969-706-G3S  | 10 Torr HexBlock orifice (20 micron), gold          |
| 969-706-G10S | 30 Torr HexBlock orifice (10.5 micron), gold        |
| 969-706-G11S | 15 mTorr HexBlock orifice (350 micron), gold        |
| 059-0835S    | Replacement c-ring, gold plated                     |

## 14.5 CDGs

The following list of spare parts should be readily available.

| Part Number | Description                  |
|-------------|------------------------------|
| 969-832-G1S | 100 Torr male HARSH gauge    |
| 969-833-G1S | 1000 Torr male HARSH gauge   |
| 969-828-G1S | 10 Torr female HARSH Gauge   |
| 969-829-G1S | 100 Torr female HARSH gauge  |
| 969-830-G1S | 1000 Torr female HARSH gauge |

## 14.6 Pumps and Maintenance Kits

The following pump and maintenance kit should be readily available.

| Part Number | Description                                                                   |
|-------------|-------------------------------------------------------------------------------|
| 969-270-G1S | Diaphragm pump, 2 stage (no cable)                                            |
| 923-418-G2  | Replacement diaphragm kit for 2-stage pump (for PU4829-N813.3, PU5200-N813.3) |

## 14.7 Consumable Parts

The following consumable parts should be readily available.

| Part Number | Description            |
|-------------|------------------------|
| 059-196     | 4-VCR gasket           |
| 059-0400    | Replacement O-ring     |
| 070-1042    | Viton O-ring (V4 only) |
| 923-706-G8  | Bypass orifice kit     |

## 14.8 Preventative Maintenance Parts

Preventative Maintenance Parts

| Part Number | Description                                            |
|-------------|--------------------------------------------------------|
| 969-818-G1S | APX CIS tungsten filament kit                          |
| 969-800-G1S | APX CIS tungsten filament kit, gold                    |
| 969-819-G1S | APX CIS tungsten ion source kit                        |
| 969-801-G1S | APX CIS tungsten ion source kit, gold                  |
| 969-819-G2S | APX CIS tungsten ion source kit with anode liner       |
| 969-801-G2S | APX CIS tungsten ion source kit with anode liner, gold |
| 961-707-G1  | Electron multiplier replacement kit                    |
| 969-241-G1S | CPM total pressure lead assy, with ceramic tube, gold  |
| 969-381-P2S | Retainer clip, kit of 6, gold                          |
| 969-369-P2S | Shield washer, kit of 9, gold                          |
| 080-007-P2S | Flat washer, SS, kit of 120, gold                      |
| 080-024-P2S | Washer 0x0.10 OD split lock, SS, kit of 120, gold      |
| 080-021-P3S | Screw 0-80 x 0.250 LG SOC HD cap, kit of 120, gold     |

## 14.9 Replacement Spare Parts

The following spare parts should be readily available.

| Part Number | Description                                        |
|-------------|----------------------------------------------------|
| 964-403-P1  | Manifold heater                                    |
| 059-0400    | Replacement C-ring                                 |
| 032-0079    | Turbomolecular pump (with CF40 flange)             |
| 969-242-G1S | Spare TiCl inlet                                   |
| 969-242-G2S | Spare TiCl inlet, xParts                           |
| 969-811-G1S | TiCl bypass kit                                    |
| 969-811-G2S | TiCl bypass kit coated, xParts                     |
| 969-713-G2S | TiCl calibration reference bracket, tubing, gasket |
| 969-716-G1S | ALD valve heater cover kit                         |
| 969-715-G1S | TiCl inlet heater cover kit                        |

## 15 Glossary

|                         |                                                                                                                                                                                                                                                                                                                                                                     |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Anode                   | The anode is the structure in the ion source in which ions are created by electron impact. It can be formed from a mesh, such as in the open ion source, or from a solid tube, such as in the closed ion source. Its electrical potential is positive with respect to the filament, focus lens, total pressure plate, pole zero, exit aperture and Faraday cup.     |
| Appearance potential    | The minimum electron energy required to produce, by electron bombardment, a given ion in its lowest energy state.                                                                                                                                                                                                                                                   |
| Atomic Mass Unit (AMU)  | An atomic mass unit is a unit of measurement for the mass of a molecule or ion. It is based on the definition that the mass of an atom of the carbon-12 isotope is exactly 12.                                                                                                                                                                                      |
| Background              | The background is the residual atmosphere in a vacuum apparatus when no gases are being deliberately introduced.                                                                                                                                                                                                                                                    |
| Bakeout                 | A bakeout is the process of heating a vacuum chamber above the ambient temperature in order to accelerate the desorption of species such as water vapor and hydrocarbons which are adsorbed onto the inner surfaces of the vacuum chamber.                                                                                                                          |
| Center voltage          | The center voltage is the DC potential to which the quadrupole rod RF and differential DC potentials are referenced.                                                                                                                                                                                                                                                |
| Closed Ion Source (CIS) | The closed ion source is an ion source in which the pressure in the ionization region is higher than in the rest of the analyzer sensor. This is usually accomplished by fabricating the anode from a solid walled tube instead of an open mesh. This type of source is usually employed to measure trace contaminant levels in a process gas.                      |
| Conductance             | The conductance of a gas flow channel is the ratio of the gas quantity flowing through the channel to the pressure drop across that channel.                                                                                                                                                                                                                        |
| Cracking pattern        | See <b>Fragmentation Pattern</b> .                                                                                                                                                                                                                                                                                                                                  |
| Detection factor        | The detection factor is the ratio of the detected signal for a given ion current from a certain substance to the detected signal for the same ion current of nitrogen ions as measured at mass 28. For Faraday cup detectors, the detection factor is usually 1. For electron multiplier detectors, this factor depends on the mass and chemical nature of the ion. |
| Detector                | The detector is that part of the mass spectrometer sensor which converts a beam of ions into an electrical signal.                                                                                                                                                                                                                                                  |
| Doubly charged ion      | For positive ions, a doubly charged ion is a parent or fragment ion where two electrons have been removed.                                                                                                                                                                                                                                                          |

|                            |                                                                                                                                                                                                                                                                                                                                |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Electron energy            | The electron energy is the kinetic energy of the ionizing electrons in an electron bombardment ion source and is typically measured in units of electron volts (eV). The electron energy is approximately equal to the difference between the bias voltage on the filament and the anode potential, times the electron charge. |
| Electron multiplier        | An electron multiplier is a <i>in situ</i> amplifier which is used to increase the sensitivity of a mass spectrometer. When a high voltage is applied to an electron multiplier, positive ions are accelerated into the multiplier, causing the release of a large number of electrons per incident ion at the output.         |
| Emission current           | The emission current is the current of electrons leaving the surface of a heated filament.                                                                                                                                                                                                                                     |
| Exit aperture (quadrupole) | The exit aperture is a focus lens at the ion exit (detector) end of a quadrupole mass spectrometer. This lens is often biased by a potential that is negative with respect to the quadrupole center voltage such that ions are extracted from the exit end of the quadrupole and focused into the detector.                    |
| Extractor                  | See <b>Focus Lens</b> .                                                                                                                                                                                                                                                                                                        |
| Faraday Cup                | The Faraday Cup is a detector for ions and/or electrons consisting of a cup shaped, conductive electrode.                                                                                                                                                                                                                      |
| Filament                   | The filament is a fine wire or ribbon, which, when heated by means of electrical current, emits electrons. The filament typically made of iridium with a thorium or yttrium oxide coating, or of tungsten or a tungsten alloy.                                                                                                 |
| Focus lens                 | The focus lens is a conductive aperture located next to, and usually biased negatively with respect to, the anode. Its purpose is to draw the ions out of the anode, form them into a beam, and focus them into the next lens element.                                                                                         |
| Fragment ion               | A fragment ion is an ion with fewer atoms than the parent gas molecule from which the ion is produced. The mass of the fragment ion is always less than that of the parent ion.                                                                                                                                                |
| Fragmentation factor       | The fragmentation factor is the fraction of the total ions produced from a specified substance which have a given mass. The sum of the fragmentation factors for all of the ions produced from a specified substance is equal to one.                                                                                          |
| Fragmentation pattern      | The fragmentation pattern is the pattern of ion masses and intensities produced by electron bombardment of a specified gas species as transmitted by the mass filter, detected and recorded.                                                                                                                                   |
| Gain (Electron Multiplier) | The gain of an electron multiplier is the ratio of incident ion current to electron current output. The gain of the multiplier is a strong function of the bias potential applied across it.                                                                                                                                   |
| Ion                        | An ion is a molecule or atom which has either lost or added one or more electrons. Those molecules which have lost electrons are positive ions. Those molecules which have added electrons are negative ions.                                                                                                                  |

|                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ion current            | An ion current is the rate of flow of electrical charge associated with the flow of ions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Ion energy             | The ion energy is the kinetic energy associated with a beam of ions. It is equal to the potential difference across which the ion beam is accelerated (or decelerated) times the charge on the ion, and is typically measured in electron volts (eV). Specifically, in a quadrupole mass spectrometer, it is the kinetic energy, along the axis, of the ions as they pass through the mass filter. The ion energy is approximately equal to the anode potential minus the quadrupole center voltage time the ionic charge.                                                                                                                                                                                                                                                                                                   |
| Ion source             | The ion source is that part of a mass spectrometer in which neutral gas molecules or atoms are ionized by electron bombardment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Ionization probability | The ionization probability for a chemical substance is the ratio of the total ion current (at all masses) produced from a given partial pressure of that substance, to the total ion current produced from nitrogen at the same partial pressure.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Isotope                | The atom is composed of nucleus protons and neutrons surrounded by an electron cloud. The chemical properties of an element are determined by the number and arrangement of electrons (with -1 charge) in an atom. The number of electrons in a neutral atom in turn depends on the number of protons (with +1 charge) within the nucleus of that atom. Atomic nuclei also contain neutrons which, being uncharged, do not affect the chemistry of an element. Protons and neutrons have approximately the same mass, which is approximately 1,800 times the mass of an electron. All atoms of a given element have the same number of protons but not necessarily the same number of neutrons. Atoms of the same element which have a different number of neutrons are called isotopes. See also <b>Natural Abundance</b> . |
| Linearity              | Linearity is the mathematical relationship between an ion current and the total or partial pressure giving rise to that current. A mass spectrometer is said to have good linearity when the ion current is proportional to the pressure over a specified pressure range within a specified tolerance. Typically (but not always), the ion current will be linear with pressure at the low end of an instrument's pressure range. At some pressure near the high pressure end of an instrument's range, the ion current will be less than proportional to the pressure.                                                                                                                                                                                                                                                      |
| Mass to charge ratio   | The mass to charge ratio is ratio of the mass of an ion to its charge, usually expressed in atomic mass units per unit electron charge.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Mass filter            | The mass filter is that part of the mass spectrometer which separates a beam of ions by their mass to charge ratios.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Mass spectrometer      | A mass spectrometer is an instrument which ionizes a gas sample, separates the resulting beam of ions by mass to charge ratio, and detects the filtered ions as an electrical signal.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

|                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mass spectrum         | A mass spectrum is a record of ion current as a function of mass to charge ratio obtained with a mass spectrometer. The spectrum can be presented as a graph with mass to charge ratio on the X-axis and ion current on the Y-axis, or as a tabular listing of ion currents and the associated mass to charge ratios.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Material factor       | The material factor for a chemical substance is that part of the proportionality constant between the partial pressure of that substance and the resulting mass filtered ion current, which depends on the chemical nature of that substance but not the particular instrument used for that measurement. The material factor is a function of the ionization probability and fragmentation factor for the specified substance.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Mean-free-path        | The mean-free-path is the average distance an ion, electron, atom, or molecule can travel before colliding with an ambient gas molecule. The mean free path is inversely proportional to the pressure.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Molecular flow        | Molecular flow is that motion of gas molecules wherein the collisional mean free path is greater than the critical dimension of a flow constraining element, such as an orifice or tube diameter. The gas flow characteristics are dominated by collisions between the gas molecules and the appropriate surfaces of the vacuum system.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Natural abundance     | <p>The natural abundance of an isotope is the average percentage of all atoms of a given element which have the same number of neutrons. For example, 99.985% of all naturally occurring hydrogen atoms have no neutrons, giving an atomic mass of approximately 1, while 0.015% have one neutron, giving an atomic mass of approximately 2. There is a third isotope of hydrogen which contains two neutrons, giving an atomic mass of 3, but this isotope is unstable with such a short radioactive half life that it is not normally naturally occurring in any significant quantity on earth.</p> <p>There are occasions when an observed isotopic abundance will not reflect the natural abundance. For instance, in semiconductor processing tools known as ion implanters, it is not unusual for the BF<sub>3</sub> boron dopant source to be isotopically enriched to 99%+ of the boron-11 isotope (instead of the naturally occurring 80.22%).</p> |
| Open Ion Source (OIS) | An open ion source is an ion source constructed with an open grid structure with high conductance between the ionization region and the vacuum region surrounding it. Residual gas analyzers are typically equipped with this type of ion source.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Outgassing            | Outgassing is the evolution of gas which was dissolved in or adsorbed on solid surfaces inside a vacuum chamber.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Parent ion            | A parent ion is an ion made by removing a single electron from the original, or parent, gas molecule, and therefore has the same mass.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

|                       |                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Partial pressure      | The partial pressure is the pressure of a specific chemical component of a gas mixture. The sum of all the partial pressures is the total pressure.                                                                                                                                                                                                                               |
| Pole zero             | See <b>Center Voltage</b> .                                                                                                                                                                                                                                                                                                                                                       |
| Quadrupole            | A quadrupole is a mass filter consisting of four parallel electrodes or poles (hence quadrupole) arranged in a square array. Opposite poles are connected together electrically such that an electric field of hyperbolic geometry is produced. The potentials applied to these poles are a superposition of variable DC and RF voltages, generally of fixed RF frequency.        |
| Repeller (electron)   | The electron repeller is an electrode located on the opposite side of the filament than the anode. The repeller is usually biased at the same potential as the negative side of the filament, or a more negative potential.                                                                                                                                                       |
| Residual gas analyzer | A residual gas analyzer is an instrument which is used to determine the quantities and chemical nature of gases present in a vacuum system. The instrument is typically a mass spectrometer equipped with an open ion source.                                                                                                                                                     |
| Resolution            | Resolution is the ability of a mass filter to select between nearby masses. It is typically measured as the mass of the peak divided by the width of a given mass peak at 10% or 50% of the peak maximum intensity.                                                                                                                                                               |
| Secondary electron    | A secondary electron is an electron emitted from a surface when that surface is struck by a sufficiently energetic ion, electron, neutral molecule or photon.                                                                                                                                                                                                                     |
| Sensitivity           | The sensitivity of a mass spectrometer is the ratio of ion current at a specified mass from a specified gas to the partial pressure of that gas, suitably corrected for background. The specified gas is typically nitrogen, measured at 28 AMU, although argon at 40 AMU is sometimes used instead, depending on the instrument.                                                 |
| Total pressure        | The total pressure is the force per unit area exerted by a gas on the walls of its container. It is equal to the sum of all the partial pressures of the different chemical species which comprise that gas.                                                                                                                                                                      |
| Total pressure plate  | The total pressure plate, or collector, is an electrode in the ion source on which at least a part of the ion beam impinges. The current striking this plate is a function of the total pressure in the ion source.                                                                                                                                                               |
| Transition flow       | Transition flow is that motion of gas molecules wherein the collisional mean free path is approximately the same as the critical dimension of a flow constraining element such as an orifice of tube diameter.                                                                                                                                                                    |
| Transmission factor   | The transmission factor is the ratio of ion current detected at the exit end of the mass filter (set to transmit a given mass) to the current of ions of the same mass entering the filter from the ion source. Typically, the transmission factor for nitrogen ions at 28 AMU is set equal to 1. The transmission factor at other masses is given relative to that for nitrogen. |

|              |                                                                                                                                                                                                                                                                             |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Viscous flow | Viscous flow is that motion of gas molecules wherein the collisional mean free path is less than the critical dimension of a flow constraining element such as an orifice or tube diameter. The gas flow characteristics are dominated by collisions between gas molecules. |
| Zero blast   | Zero blast is the ion current which is not mass filtered and is detected when the mass spectrometer is scanning near mass zero.                                                                                                                                             |



