Lab 6: Leak Detection

LEAK DETECTION LAB

In this lab we will be using a VARIAN helium leak detector to find leak(s) on INDY. Helium Leak detectors are common, sensitive, and easy to use diagnostic tools used to locate leaks in vacuum systems. A typical helium leak detector is simply a mass spectrometer, or Residual Gas Analyzer (RGA), tuned to see helium. Gas entering a standard RGA is analyzed in the following manner. As the gas enters the system, an electron beam is used to ionize the gas. These new ions are then accelerated to a relatively high energy (usually around 50 eV). At this point the ions are sent through a mass analyzer that takes into account the energy of ions. Often this analyzer is a magnetic field which causes the ion to rotate at the Larmour radius.

$$r_c = \frac{v_{\perp 0}}{\omega_c}$$

$$= \frac{\left(2qV_a / m\right)^{1/2}}{qB/m}$$

$$= \frac{\left(2mV_a / q\right)^{1/2}}{B}$$

Note that the radius is dependent on the mass, the magnetic field strength and the charge and energy of the ion. Because this radius depends on the mass of the ion, different masses can be selected by blocking all radiuses except the one of interest. Often, a single radius is selected and then the mass of interest is picked by either adjusting the energy or the strength of the magnetic field. For a Helium leak detector, the magnetic field and the acceleration are left at constant values; tuned to allow only Helium ions through.

First of all there is no such thing as a "PERFECT VACUUM CHAMBER". Everything leaks, it's how much and will it hurt your process that matters. A good practice is to keep a log of BASE PRESSURE for each vacuum chamber. You should take your base pressure reading after the vacuum system has pumped for some time (overnight is good but not always possible in a production environment). This can tell you when a possible leak develops. If you notice a rise in your base pressure it's a sign there could be a leak. Leaks can contaminate vacuum systems, which in turn can result in unusable product (wafers) or unwanted process.

We use helium for leak detection because it is the lightest and smallest of inert gas molecules. In addition, it is fairly rare in earth's atmosphere, which contains only about 5 parts per million. In comparison when the leak detector is in use, one often uses pure He as a probe. This makes it easy to distinguish between the helium in the atmosphere and that from the probe. This makes it useful in locating small leaks. In addition, because He is so light, it has a tendency to backflow in high vacuum pumps. Thus it is common to put the gas detector on the high vacuum side of a high vacuum pump and yet attach the

system to be examined to the low vacuum side of the detector system. Helium is also a nonreactive, nonhazardous, and nontoxic gas and thus, it permits you to test vacuum systems with unfriendly environments. One problem with the use of Helium is that because it is light it also tends to migrate and thus can give false readings. This problem can be overcome because helium is a light gas and tends to float upward. If you start at the top of what you are testing and work your way down to the bottom, you reduce the problem associated with Helium migration. Finally, you must use any inert gas in a well-ventilated area and be careful of asphyxiation.

In order to know your leak detector is actually seeing helium we use something called a "CALIBRATED LEAK". This consists of a metal tube that has a Pyrex glass finger inside it with a shutoff valve. The metal tube contains Helium, which permeates through the Pyrex glass finger at a recorded rate. This value is posted on the calibrated leak. With the shutoff valve closed you can zero the leak detector. With the shutoff valve open you can calibrate the leak detector to the value posted on the calibrated leak. A calibrated leak should be stored with the shutoff valve in the open position when not in use so as not to saturate the inside of the calibrated leak. The leak rates on calibrated leaks are so small that it would take many years for all the helium to leak out with the valve open. If a calibrated leak has a volume of 150 cc with a leak rate of 8.4x10-8 atm. cc/sec it would take 1,785,714,286 seconds or 57 years to empty the calibrated leak.

Laboratory procedure:

1) Start the VARIAN leak detector as per the instructions on the inside of the door. With the shutoff valve on the calibrated leak closed set the zero on the leak detector. Then open the valve and calibrate the leak detector as close to the recorded values on the calibrated leak. Can you calibrate the leak detector to the calibrated leak? If not, why?

2) Record the base pressure using the Hot Cathode Ion Gauge. Hook up the leak detector to INDY via the manual shutoff valve located on the left hand side of the chamber. With the Throttle/Gate valve open start the test according to the instructions on the inside of the leak detector door. Set the helium probe flow by placing the tip of the probe in a container of water and adjust the regulator until you get approximately one bubble per second coming from the probe tip. Using the TOP to BOTTOM method spray helium around a flange or seal and wait a few seconds. When a leak is found you will hear an audible alarm and see a rise on the bar graph located on the leak detector. When a leak is indicated record the leak rate and the time it takes for the signal to settle. Now close the Throttle/Gate valve and retest the location, record the leak rate and settle time. After a leak has been located and recorded fix the leak and start checking the remainder of the flanges with the Throttle/Gate valve open and also closed. Find, record, and fix all leaks.

3) After all leaks have been found, recorded, and fixed make sure Throttle/Gate is open and the ion gauge is on. Close the manual shutoff valve and record the base

pressure. Open the manual shutoff valve and spray Helium in the Vent/Purge valve on the Turbo and record the leak rate and settle time. Explain what happened and why.