DUNIWAY STOCKROOM CORP.

Supplying reliable vacuum equipment since 1976!

Field Emission Currents in Ion Pumps

Using the Terranova 741 to Diagnose Field Emission Leakage

One of the many advantages of using sputter-ion pumps, is that the discharge current is approximately proportional to pressure over wide ranges, from 10-4 torr to 10-10 torr.

However, after extended use and multiple bakeouts, deposits of sputtered material can build up. Some of these deposits may generate sharp points between the cathode and anode of the pump. These sharp points, in the presence of the 5 KV to 7.5 KV operating voltages of ion pumps can give rise to field emission leakage currents.

The field emission currents can be several microamps in magnitude, thus masking the true discharge ion current. For example, in a typical 100 l/s ion pump, a field emission leakage current of 5 microamps would start to mask pressure readings below 10-8 torr and make readings in the 10-9 torr range impossible. In addition, in many cases, the field emission current has a ‘noisy’ appearance with

10-20% variation. The existence of field emission leakage can be verified by removing the pump magnets, and observing the current. Any current would be due to non-discharge/pumping mechanisms. However, removal of magnets on larger pumps, while installed on a system can be awkward.

With most ion pump control units it is difficult if not impossible to diagnose such leakage currents. In addition, low voltage resistance measurements show nothing, because the field emission leakage currents rise exponentially with voltage, and at V-O-M voltage levels the current is extremely small. Figure 1 below shows a typical graph of field emission current (lower, exponential curve) versus voltage. (Actual curves may be the sum of the linear ion current and the exponential field emission leakage current, but the exponential component should be obvious.)

However, with an ion pump control unit like the Terranova 741, the ion pump operating voltage can be adjusted during operation. So, when low pressures should have been reached, but the ion pump current is reading a few microamps, it is straight forward to use the SETUP function to vary the high voltage from 3.5 to 7.5 KV (steps of 1 KV should tell the story) and record the current for each voltage setting. If you get a curve with the exponential shape, like the lower curve, your pump has more than likely developed field emission leakage.

Field emission leakage currents do not in any way interfere with or diminish the ion pump's ability to pump. They only mask the ability to use the pump current to indicate the pressure at the bottom of the pressure range. In smaller pumps, with only a few anode cells, field emission may actually speed up the striking of the discharge at UHV pressures, by contributing the initial electron required to start the avalanche.

This condition can usually be remedied by "Hi-Potting" the pump, by applying significantly higher voltage (15-20KV) to the high voltage feedthrough. The high, exponential currents flowing through the fragile field emission points will usually burn them off. Sometimes, judicious light tapping with a non-magnetic object can break the field emission points loose, also. Call Duniway Stockroom Corp. to obtain information on "Hi-Potting" apparatus.

If, on the other hand, you find a more linear relationship between applied voltage and current, it is most likely due to real ions, thus indicating the pressure in the system. If the current and therefore the pressure are higher than expected, well, you probably have a leak or need more time and bakeout cycles to get the pressure down to desired values.

In unusual cases, linear current versus voltage might indicate a resistive load. This could be dirt or fingerprints on the external ceramic portion of the high voltage feedthrough. In that case, cleaning with solvent and DI water, with mild heating with a heat gun will take care of the leakage. If, however, the resistive coating is on the internal ceramics of the ion pump, a complete cleaning and processing is required. Such resistive coatings could come from extended operation of the ion pump at high pressures where the glow-discharge is not confined to the pump's magnetic field. Or, the coatings could come from active metals, such as barium, cesium, etc. which may have been present in the vacuum system and deposited out on the ion pump insulators.

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