Tech TOPICS

Universal Gas Analyzer Measures from Atmospheric Pressure to UHV, and can Handle Corrosive and Low Molecular Weight Samples

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Residual gas analyzers (RGAs) have long been used to characterize the components of a gas mixture. They are based on a quadrupole mass spectrometer with a hot filament ionizer. A turbomolecular pump (TP) is commonly used to generate the high vacuum region ($<10^{-5}$ Torr) required to operate the ionizer and quadrupole. More recently, a variety of applications for atmospheric sampling were developed including fuel cell research, Freon detection, specialty gas production monitoring, fermentation process monitoring, and catalysis studies. To accommodate atmospheric sampling, a pressure reduction scheme is required. Most commercially available systems employ a capillary tube, pinhole, and single diaphragm pump (DP) to reduce the pressure exposed to the RGA. The DP performs double duty, evacuating a bypass line and backing the TP. The drawback to this architecture is that the DP will allow some of the gas in the bypass line to backstream through the TP. As discussed below, this backstreaming can cause real problems for users measuring corrosive or low molecular weight gases.

System Architecture

Stanford Research Systems (Sunnyvale, CA) has designed a universal gas analyzer (UGA) employing two separate DPs. A two stage pressure reducing inlet samples gases at high pressure (see **Figure 1**). An atmospheric pressure gas sample is drawn through the capillary which drops the pressure 3 decades. A small amount of gas sample is drawn by the TP through a pinhole (30 mm) which reduces the pressure to about 10^{-6} Torr, while most of the inlet gas flow (about 99.9%) flows directly to the bypass DP. In the single diaphragm pump configuration, the bypass flow is recombined with the sample flow at the DP. This causes backstreaming of light molecular weight gases (e.g. hydrogen, helium). When high concentrations of corrosive gases are used, this backstreaming pathway also allows a fraction of the corrosive gas to reach the RGA and TP. Exposure to corrosives can dramatically shorten the usable life of the RGA filament and the TP.

A demonstration of the problem and its solution is shown in **Figure 2**. The figure shows data taken on a mixture of 5% hydrogen in nitrogen. The red traces in the figure show the detector response with the sample valve open, while the blue traces show the response with the valve closed. In the single DP configuration, the RGA still picks up significant concentrations of hydrogen from backstreaming. However, in the dual DP configuration, when the sample valve is closed the hydrogen signal drops to a level consistent with internal degassing. The data show the backstreaming problem is virtually eliminated in the dual DP system employed by the UGA.

Feature Highlights

The RGA chamber is a six-way cross with 2-3/4" conflat flanges. Two ports are available for direct connection to various vacuum regions (from 0.1 Torr to 10^{-7} Torr) using the proper connection, or the user can use the built-in capillary pressure reduction system to sample atmospheric pressures (See **Figure 3**). This capability makes it possible to use the UGA as a helium leak detector or for other "sniffing" applications. Several heaters (standard equipment) cover the sample inlet, chamber, and the connection to the TP. Bakeouts up to 120°C can be performed easily and safely; all the heaters are under microprocessor control.

The user can directly control all the pumps, valves and heaters from

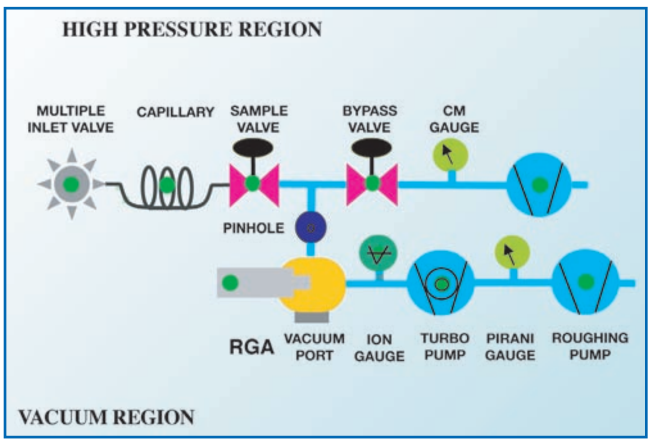

Figure 1. UGA schematics

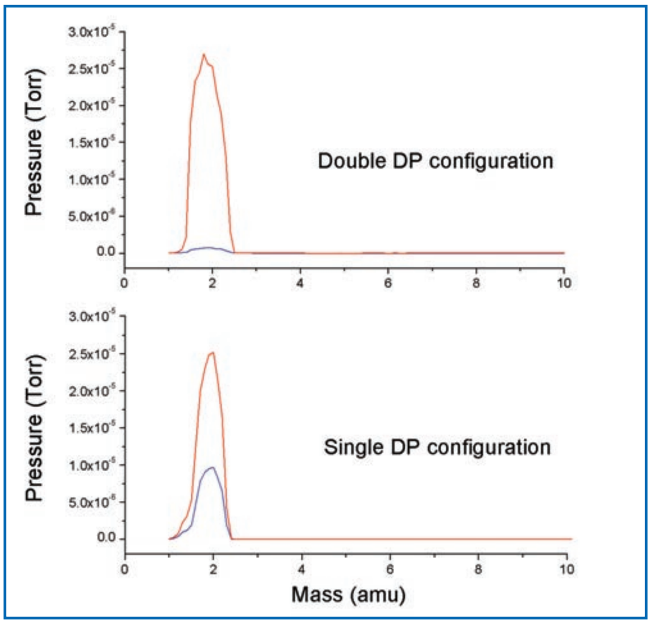

Figure 2. *Results of the H2 measurements from two different configurations; Single DP and Double DP. The red traces indicate the detector response with the sample valve open, while the blue traces show the response with the valve closed.*

the front panel. A convenient display allows menu-driven operation. A capacitance manometer, pirani gauge, and an ion gauge monitor the status of the system continuously and their data are all available from the front panel. The variety of gauges allows the system to automate the pump down procedure and to implement interlocks for unattended fail-safe operation.

The system may be configured with a multiple capillary inlet valve, allowing the user to monitor up to 16 different capillaries at various locations in their system. Some ultra high vacuum and ultra clean chambers cannot tolerate venting with ambient air because of the water vapor present. An optional valve allows venting with dried nitrogen or other gas supply.

The UGA is densely packed. All the components – two DPs, one TP, the chamber, the RGA, three gauges, two solenoid valves, heaters and the insulating cabinet, and power supplies; are packed in a box of 12"(W) × 11"(H) × 25"(L). The system is designed to run in either a horizontal or vertical orientation (See **Figure 3**). This flexibility in siting the instrument means it can fit almost anywhere in a vacuum lab.

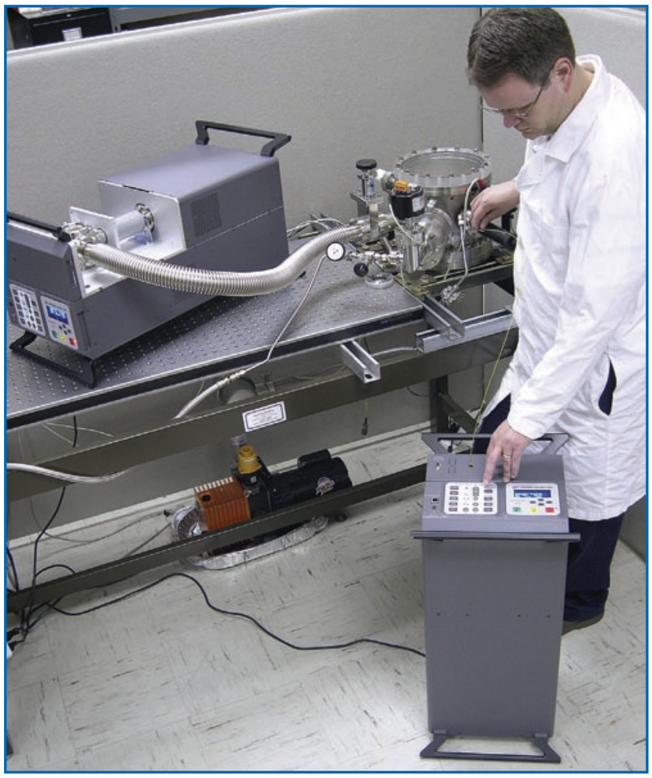

Figure 3. *Two sample inlets (a capillary and a high vacuum inlet) are shown. And the operating orientations of the UGA, horizontal and vertical, are demonstrated.*

Remote Interfaces and Software

The UGA software supports both RS-232 and Ethernet remote interfaces. The Ethernet opens up new possibilities for gas analysis; the PC can be located literally miles away from the UGA, and wireless connections can be made. This makes hostile environments easy and safe to analyze. The Ethernet also makes monitoring multiple UGAs from a single PC simple to set up.

The software is included with the instrument and provides an intuitive graphical user interface to the controls (See **Figure 4**). All the pumps, valves and heaters may be controlled with the software. Every operation that takes place (valve open or close, pumps turned on or off, heaters activated, etc.) is logged as a timestamped "event" by the software. The event log is stored as a file on the PC hard drive. The log can be very useful for troubleshooting; if a user finds the UGA's interlocks activated while he was away, the event log will show what gauge registered an overpressure and when. This allows the user to track exactly where a problem began instead of guessing what went wrong. This can save hours of time in debugging a vacuum process.

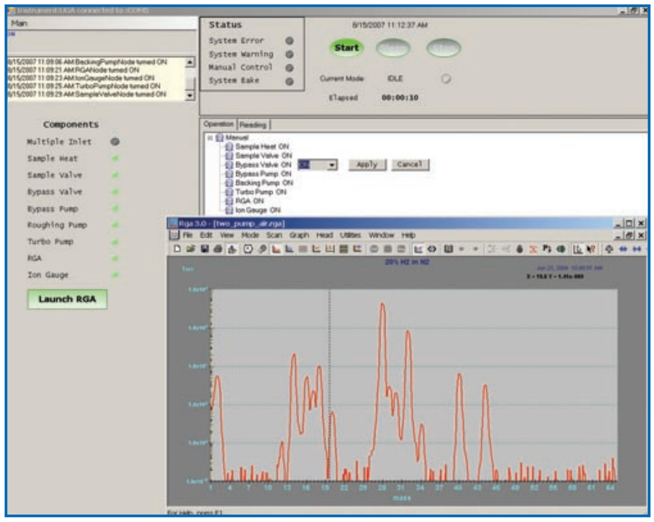

Figure 4. *UGA control software running with RGA control software.*

Summary

Overall, the UGA has several features to increase productivity of vacuum scientists. The sample inlet gives fast response times. The dual DP architecture eliminates backstreaming giving the user flexibility to analyze corrosive or low molecular weight gases. Eliminating the backstreaming also lowers the cost of ownership by increasing the lifetime of the TP and the RGA filament. The Ethernet interface allows truly remote operation. These features offer a good combination of performance and flexibility.