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Technology for Productivity

Application Note

Note #01/08

Increased Electron Multiplier Lifetimes Through Intelligent Data Acquisition

BACKGROUND

The electron multiplier (EM) is an extremely sensitive RGA detector. It allows the measurement of partial pressures as low as 10^{-14} Torr through the action of ionized residual gas molecules impacting an active film on the EM detector surface. This impact releases free electrons that cascade through the detector channels with each surface impact creating more free electrons. This magnifies the original ion signal by factors of hundreds or even thousands. The active film in an EM degrades over time. The lifetime depends upon various factors, especially on vacuum quality and the impact of ion concentrations at or above the operational limit of the detector.

The quality of the vacuum is determined by the pumping system, the out-gassing of materials in the vacuum, the purity of the gases used in the vacuum system and the security of the vacuum interlocks that prevent exposure of the energized detector to poor vacuum. The MKS RGA design incorporates strong interlock provisions to protect the electron multiplier. The vacuum and inlet designs follow best practices, minimizing gas impurities in the detector area of the vacuum chamber.

Traditionally, ion concentrations above the operational limits are avoided by first surveying the spectrum of any unknown gas mixture using the less sensitive but more robust Faraday detector. Then, if necessary, the experienced RGA user can choose to measure the data with the electron multiplier in "peak jumping" mode so that the large gas peaks can be avoided, preventing damage to the detector. In a process control environment where the gas mixture can change quickly over large pressure ranges, this level of operator involvement is not practical, so many users become accustomed to replacing their electron multiplier after only a few months of use.

As the multiplier ages, either normally or at an accelerated rate due to frequent measurement of high ion signals, the voltage applied to the EM must be increased in order to maintain the signal gain needed for accurate analyses. Typically, RGA software automatically corrects for this aging process, but as the increased EM voltage approaches the allowed maximum, it is often possible to see random "spikes" in the collected signals. This is due to discharges that can occur when the detector is operated at the higher voltages. These discharges can cause false positive readings which, for RGA systems, can produce unwanted process control alarms.

For this reason, many users change detectors earlier than might normally be necessary in order to prevent false readings. This results in a higher cost of ownership over the lifetime of the instrument.

To resolve these issues and improve the data quality for RGA users, MKS has released version 5.61 of Process Eye™ Professional and version 1.27 of TOOLWeb® RGA. These new releases address the problems of detector damage from high signal measurement and data spikes due to aging detectors.

EM PROTECTION BY INTELLIGENT DATA ACQUISITION

These new MKS software releases allow the user to explicitly choose peaks that are not to be measured in normal data acquisition. For example, when the bulk gas is known, then the mass peaks for those gases can be set as "skipped" in the data acquisition parameters as shown in Figure 1:

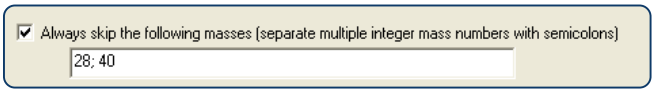

Figure 1 - Setting the mass peaks that should always be skipped (in this case nitrogen and argon).

When the composition of a gas mixture is unknown, the software can be set to skip any peak that has measured at full scale for a set number of consecutive readings. If the gas which caused the high signal is expected to come back within range at some later point, the software can be set to resume measurement of the peak again after a period of time. Should the gas peak remain too high on resumption of measurement, the software will re-initialize the cycle. Figure 2 shows how this arrangement is entered in the Process Eye Professional recipe.

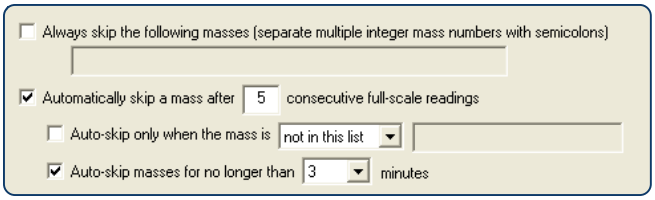

Figure 2 - Selecting the parameters for a cycle of skip-and-retest of selected peaks.

EM PROTECTION (CONT.)

Skipped peaks are marked in the data to show that they measured as over-range. Also, if the skipped peak's measured value is used as a parameter in any index or alarm calculation, the data is flagged for that scan and an alarm would be treated as if the peak were measured at its maximum value. Figure 3 shows how skipped peak data is displayed in the Recall program of Process Eye Professional:

EXTENDING THE LIFE OF DETECTORS AND PROTECTING DATA QUALITY

Even when best vacuum practices are followed and intelligent data acquisition is used to prevent detector exposure to excessive signals, the EM active film surface will naturally degrade over time, giving rise to spikes in the data. If the spike appears in a gas peak used for an alarm check, this can lead to false positive readings and an alarm. In the worst case, this would result in a tool stoppage and the loss of production when no real problem exists. In the best case, an engineer must examine the data to evaluate the alarm before permitting production to continue. Both of these situations reduce FAB productivity. Furthermore, if the RGA data is not deemed trustworthy, true contamination events may be missed while awaiting an engineer's review, this leading to scrapped wafers and possibly chamber contamination causing an unscheduled PM.

Process Eye Professional 5.61 and TOOLweb RGA 1.27 software allow each data point in a scan to be compared with the same data point in prior and post scans to determine whether a spike has corrupted the data. When such data corruption is detected, the peak is displayed in red and labelled as skipped (Figure 4).

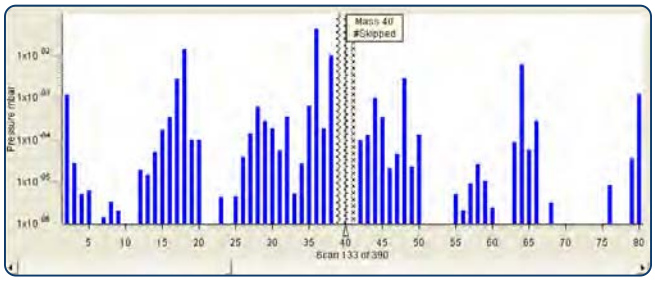

Figure 3 - The display for skipped data in a bar chart scan.

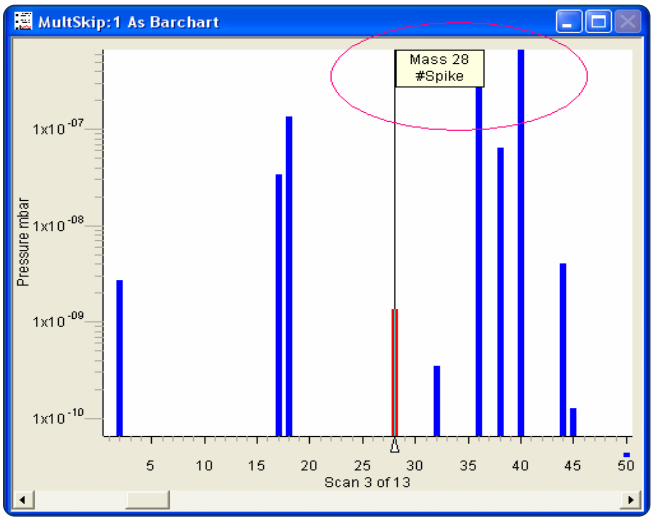

Figure 4 - A data spike detected and flagged in a bar chart scan.

EXTENDING THE LIFE (CONT.)

Data that have been flagged as spikes are not used in index or alarm calculations, and the reported values are calculated from the surrounding scans. Spike data are clearly indicated in the trend displays and, with TOOLweb RGA, a spike index denoting the number of data spikes per hundred data points is displayed for each wafer. A warning is displayed if excessive data spikes were experienced during wafer processing as is shown in Figure 5.

Spike data is also used in calculations that indicate the health of the EM detector. Warning and alarm messages are generated indicating the need for a detector change at the next PM or the presence of a spike index so high that data may be unreliable. Effective use of these warnings results in the best data quality and the maximum usable life of an EM detector.

CONCLUSION

The use of Process Eye Professional 5.61 and TOOLweb RGA 1.27 software will produce significantly improved RGA data quality. Intelligent use of the data collection and data processing options available in this software results in an extension of the usable lifetime for an EM detector with reduced operating costs, more reliable data for RGA systems and, consequently, reductions in unnecessary process line stoppages.

Figure 5 - Trend display showing the number of data spikes during individual wafer processing.

For further information, call your local MKS Sales Engineer or contact the MKS Applications Engineering Group at 800.227.8766.
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