TECHNICAL NOTE

Transpector® 2 Improvements Lead to Better Process Monitoring

As processes in the semiconductor industry become more complex, and the number of variables that need to be controlled increases, the ability to acquire reliable chamber background and processing data becomes more important. This data helps the process engineer gain a clearer picture of what is going on in the system and make informed decisions in the event that there is a process problem. To increase the range of useful data acquired by the Transpector system, a number of improvements have been made to the electronics. These include improvements to the quadrupole controller, to the data acquisition board, and the overall circuitry to increase efficiency. These changes have resulted in a substantial reduction in noise as well as a reduction in zero blast, which allows better monitoring of low mass signals at process pressures. Improvements in the RF control also result in a superior abundance-sensitivity measurement.

NOISE

The amount of background noise directly influences the minimum level that can be detected by an instrument. Noise in the Transpector is the variation in the baseline signal and is usually measured at the background pressure of the vacuum system. This is done to avoid any interference from ions and also from fluctuations due to changes in ion statistics and pressure. By decreasing the noise in the measurements the Minimum Detectable Partial Pressure (MDPP) for the various gas species is improved. Figure 1 shows a comparison of the noise levels between Transpector and Transpector 2.

The data for the various dwell times (Dwell = time that we take to measure ion information for each point), in Figure 1 have been offset so that noise levels can be observed clearly and compared. It is apparent that noise increases with shorter dwell times. This is because less signal is acquired per data point, resulting in larger variations between measurements. Therefore, as the analyzed signal decreases, the sampling time must be increased to obtain an acceptable signal-to-noise ratio.

MINIMUM DETECTABLE PARTIAL PRESSURE

For performance comparisons among different residual gas analyzers (RGAs), a useful number for the engineer is the MDPP. MDPP indicates the minimum amount of signal that can be observed under specified conditions. For the data shown here, the minimum detectable signal is defined as the standard deviation of the noise level, or MDS = Std Dev (Signal). Since the partial pressure of a gas species in a process chamber is the quantity of interest, this can be converted to an MDPP using the Transpector's sensitivity. Sensitivity is measured inamps/Torr and so the MDPP (Torr) = MDS(amps)/Sensitivity (amps/Torr). For comparison purposes a sensitivity of $2x10^{-4}$ amps/Torr is used since this is the minimum acceptable sensitivity for the Transpector 2.

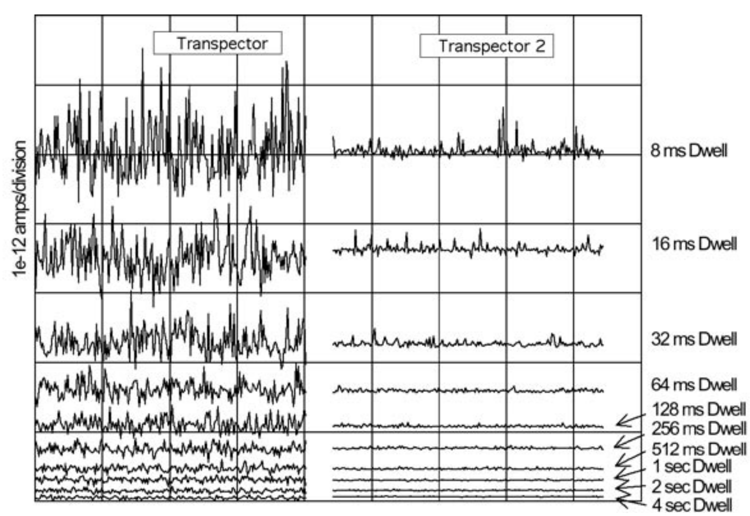

Figure 1: EM Noise Comparisons Taken at High Vacuum

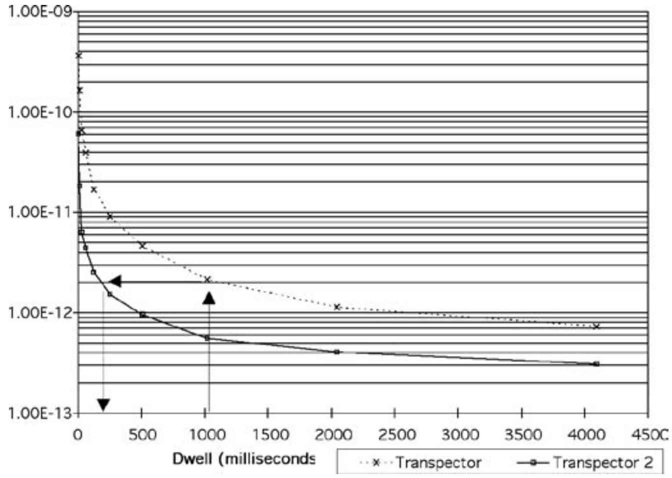

Figure 2: Minimum Detectable Partial Pressure (MDPP) Comparisons Between Transpector and Transpector 2

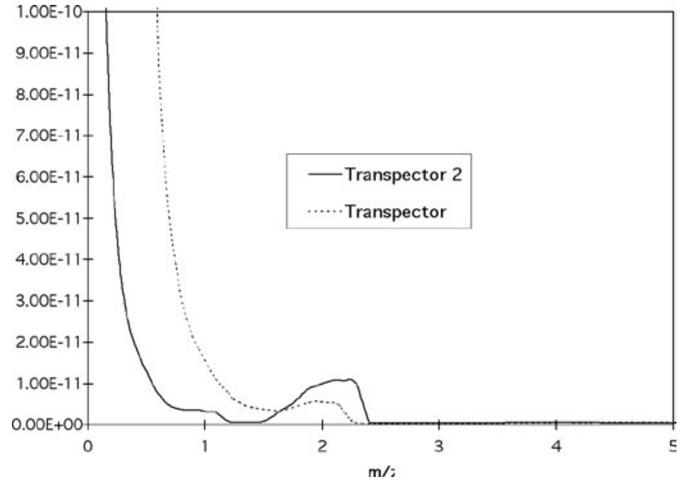

Figure 3: Zero Blast Comparison at $1x10^{-5}$ Torr

Figure 2 is a plot of the MDPP for Transpector and Transpector 2 as a function of dwell time. A lower MDPP indicates a better limit of detection for an instrument, and in all cases the Transpector 2 has an improved detection limit. One result of this that the same detection limits can be obtained in a much shorter measurement time. This is indicated in Figure 2 by the horizontal line drawn between the two curves. The same MDPP can now be obtained in 256 milliseconds instead of the 1-second dwell needed with the original Transpector electronics. This allows much faster data acquisition and a much better likelihood of detecting transient events while monitoring processes. The increase in speed and detection limit allows more flexibility in the design of a monitoring method for a given manufacturing process.

CIRCUIT CHANGES

Several changes have been made in the circuitry to improve the detection of low-mass peaks, to decrease peak drift with time, and to increase spectral resolution. The RF frequency is now digitally synthesized and crystal-referenced to obtain a much more stable spectra, resulting in a significant reduction in the need to tune for sensor mass position or resolution. The electronics also perform an automatic resonance of the RF circuit. This results in lower noise at faster dwell times that can help in both leak detection and in process monitoring applications. The RF frequency also has been increased, providing an increase in voltage and field strength throughout the mass range. The increased field strength, along with improved frequency control through crystal-referencing, dramatically improves mass discrimination in the low-mass range. This has resulted in a decrease in the interference due to zero blast and an increase in peak intensities and resolution. By improving the RF control and increasing the field strength, the current due to zero blast can be minimized. Figure 3 is a comparison of Transpector and 2 low mass spectra at $1x10^{-5}$ Torr argon. It shows the large reduction in zero blast.

These improvements have not only increased the capabilities of the Transpector system as a residual gas analyzer, but also as a true process monitor. The ability to see clearly the low mass peak as well as low-level peaks near major gas components allows users to detect contaminants that may have drastic effects on the process, and on the quality of the final product.

CONCLUSION

With these capabilities to monitor process gases, the Transpector 2 system will help engineers better understand vacuum and semiconductor manufacturing processes.

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