INFICON

TECHNICAL NOTE

FabGuard® HYT *In Situ* Particle Monitor and Tool Data Sensor

FabGuard Sensor Integration and Analysis System is a fully automated, real-time early fault detection and analysis system for improving semiconductor equipment and process productivity and various INFICON *in situ* diagnostic sensors. The powerful analysis techniques of FabGuard are capable of "smart diagnostics" by combining sensor and tool data for fault detection and classification. FabGuard puts *in situ* sensors to work to:

• Baseline normal process and tool behavior

• Analyze process data in real-time to detect problems and pinpoint problem sources

• Issue warnings and alarms

One of the benefits of FabGuard to your process is using data from more than one type of sensor. In this case, an HYT *in situ* particle monitor was used with data from the processing tool to detect, and determine the cause of, unacceptably high particle levels.
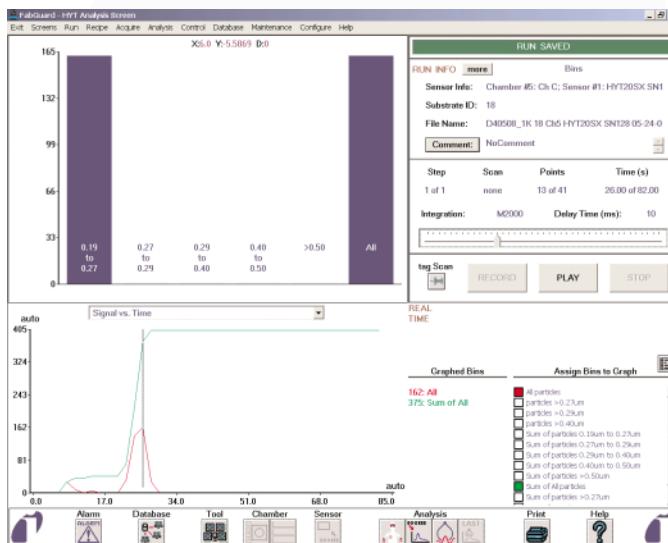
Figure 1. HYT particle counts for a normal wafer.

Figure 1 and Figure 2 show that the HYT sensor can easily distinguish between low and high particle counts in an etch preclean chamber. Figure 13 shows the particle counts for a normal wafer. The lower plot shows the time series data from two Bins: the number of particles of any size for each time interval (red) and the cumulative sum from wafer start of the number of particles of any size (green). The maximum number of particles for any one-time interval was 162. The total number of particles accumulated over the entire process was 402, which was typical for this process. The upper left plot indicates that essentially all of the particles were small, 0.19 to 0.27 microns, which was typical for this process.

Figure 2. HYT particle counts for a wafer with abnormally high particle counts.

Figure2 shows the particle counts for a wafer that had particle problems. The maximum number of particles for any one-time interval was 1138, which is 7 times higher than the normal wafer. The total number of particles accumulated over the entire process was 5644, which is 14 times higher than the normal wafer. These particle counts were high enough that FabGuard generated an alarm and sent an alarm message to the processing tool.

WHAT CAUSED THE HIGH PARTICLE COUNTS?

Figure 3 shows how TDS and HYT data combined to help pinpoint the particle problem. TDS collected the following variables: Pressure (capacitance manometer), Pressure (ion gauge), RF-1 Forward Power, RF-1 Reflected Power, RF-2 Forward Power, RF-2 Reflected Power, Chamber Slit Valve Open/Closed, Argon Flow (standard AFC), and Argon Flow (low flow AFC). RF power, especially RF-2, proved to be the most strongly correlated with the high particle counts. Pressure and gas flow were not significantly correlated with particle counts. The figure shows the time series data from three Bins for both the normal and abnormal wafers: the number of particles of any size for each time interval (red), the RF-2 Forward Power (green), and the RF-2 Reflected Power (blue). The vertical axis uses different scaling for each Bin.
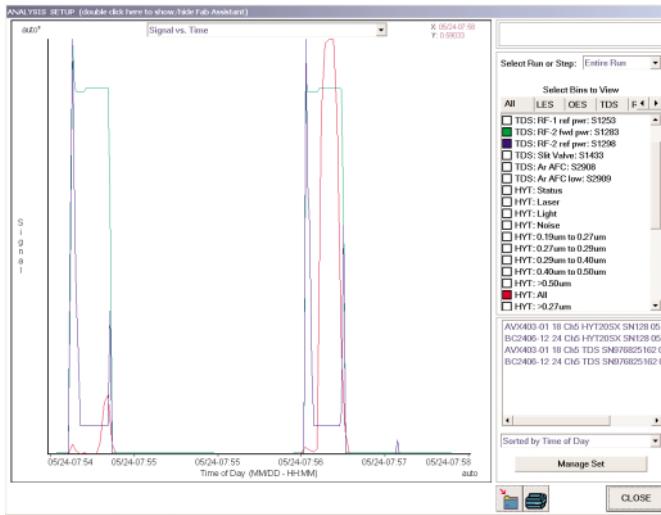

Figure 3. Correlation between HYT particle counts and RF-2 forward and reflected power.

The normal wafer has a small particle peak when RF-2 turns on and a larger peak when RF-2 turns off. Both of these particle peaks turn out to be typical for this process, because some particles are produced when the RF-2 reflected power is high. The abnormal wafer is different because it has a much larger and broader particle peak during the middle of the process.

Both processes used the same recipe, so the different particle counts were not caused by differences in the recipes. Notice that the large particle peak in the abnormal wafer starts about 8 seconds after RF-2 turns on. This time delay indicates that the particles are produced only after the plasma has been on for several seconds. This implies a few possible sources of the particles: (1) they could have formed in the plasma, (2) they could have been generated by the interaction of the plasma with the chamber walls, or (3) they could have been generated by the interaction of the plasma with the wafer surface. The first two possibilities were ruled out because the normal and abnormal wafers were processed one right after the other. This left only the interaction of the plasma with the wafer. It turned out that the important difference was that the two wafers came from different lots. In fact, every wafer in one of these two lots exhibited about 10 times higher particle counts than normal. In other words, the incoming wafers were causing the particle problem. Using the Lot IDs maintained by FabGuard, the cause of this problem was tracked to one specific upstream tool. When this upstream tool was repaired, the particle problem went away.

INFICON The Instrumental Difference®