INFICON

APPLICATION NOTE

Transpector® CPM – Integrated Process Monitor for 300mm High Pressure Degas

The Transpector CPM Integrated Process Monitor is a fully-integrated gas analysis system capable of real-time degas monitoring and upstream process fault detection to ensure good product yield and throughput of physical vapor deposition (PVD) equipment for semiconductor manufacturing. The Compact Process Monitor (CPM) is a full-featured, compact and affordable gas analyzer that is ideal for *in situ* monitoring of high pressure processes. With the wide variety of contamination issues present in the degas process, a tightly integrated *in situ* sensor can provide important clues on how best to handle incoming contamination events.

300MM HIGH PRESSURE DEGAS PROCESS

A developing metallization wafer always absorbs water vapor, other gases and impurities (e.g., hydrocarbons and photoresist) from the previous processes. These gases and impurities degrade film properties and therefore must be desorbed and driven off the wafer before further films are deposited. The wafer degas module is intended to fulfill this requirement in a PVD cluster tool.

Because of the wafer's bigger geometric size, the traditional clamped degas, which utilizes infrared radiation to heat the wafer, is not suitable for a 300mm wafer. Instead, a higher pressure degas is used in most 300mm PVD cluster tools. Argon gas is filled into the chamber until it reaches a pressure at which wafer heating occurs primarily via gas conduction from a heated chuck. Wafer heating and degassing occur uniformly regardless of pre-existing wafer patterning.

Degas process monitoring using an Integrated Process Monitor (IPM) is critical to insure good product yield and throughput of a PVD cluster tool. Not only do these chambers see the worst of what is potentially on a wafer with regards to contamination, they are of critical importance in ensuring the complete removal of volatiles that will adversely effect deposited films. Additionally, these impurities are not only a danger to the individual wafer but could also contaminate the tool itself. Therefore, integrated process monitoring is a key enabler for process control, improving process yields and productivity for metallization.

IPM INSTALLATION

Due to the high pressure utilized in 300mm degas, a Transpector CPM with a differential pumping system is employed for process monitoring. Furthermore, a sniffer sampling system is used to reduce the diffusion time for the offgassing from the release point on the wafer to the inlet of RGA sampling system, thus reducing the RGA response time. Figure 1 compares the wafer degassing profiles with and without the sniffer sampling system.

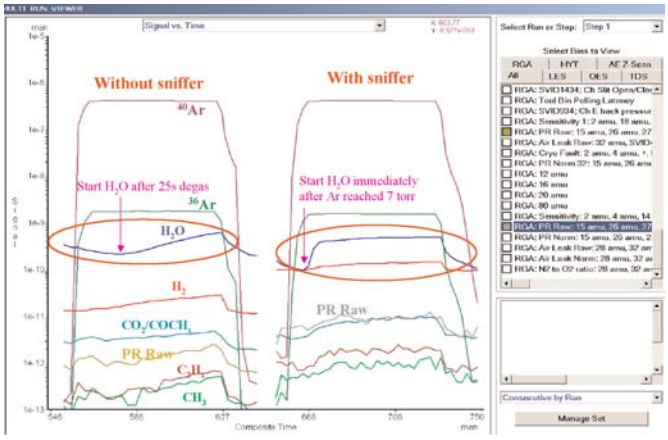

Figure 1 - Comparison of wafer degassing profiles with and without sniffer.

Because there is no gas flow during the degas process, the diffusion time is determined by the gas diffusion length, which is related to wafer location with respect to the RGA sampling system typically mounted on the chamber wall. By installing a sniffer (Figurure 2) onto the wafer edge, the offgassing can be sampled directly from its release point by the gas analyzer without dilution and thus reduce the diffusion time.

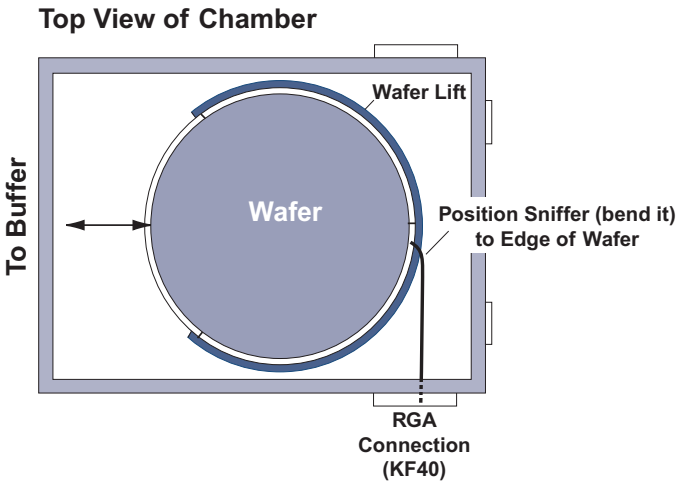

Figure 2 - CPM Sniffer Inlet Installation.

After a high pressure degassing process, the chamber is evacuated first via a rough pump and then by a cryopump. Wafer heating and degassing continues to occur even as the chamber is being pumped out for wafer transfer, due to the presence of the heated chuck.

The monoblock design of the CPM inlet not only provides for high pressure sampling, but also has a high-conductance option which is designed to allow direct sampling of the chamber background by the ion source without an orifice. This multi-inlet technique allows direct monitoring of the pumpdown and base pressure state with improved sensitivity compared to high pressure. The INFICON Transpector CPM IPM System allows auto-switching of the sampling valve to obtain a four decade wide dynamic pressure change based on the wafer process step. This synchronization of sensor function to process and equipment state is critical in providing the most accurate and valuble information from the IPM. Figure 3 shows a typical wafer degassing and pumpdown as monitored by the IPM.

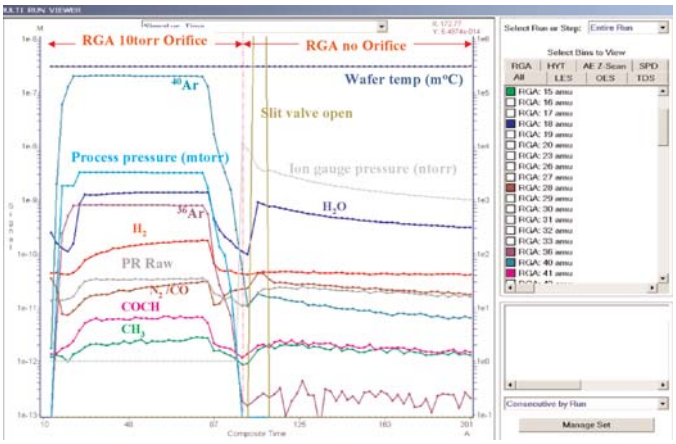

Figure 3 - A typical wafer degassing and pumpdown monitor with IPM.

FAULT DETECTION

Many different types of wafers can potentially be run through the same tool for different deposition layers. Each of these will have different up-stream processing characteristics based on the underlying layers, such as: photoresist ash and strip, oxide or low-K etch, dielectric or low-K deposition, oxide and metal plug (W) polish, wet clean, DI water rinse and dry. Each of these has the potential for contamination caused by leftover photoresist, residual solvent or low-K dielectric materials instability. Therefore, the wafer might have a variety of different outgassing “signatures” based on previous processing sequences.

Previous Process Fault Identification

The Transpector CPM IPM System monitors every wafer’s outgassing in real-time and can recognize and isolate the contamination quickly by defining special analysis signals to identify various materials from prior processing steps. The Transpector CPM IPM System also pulls wafer information such as lot ID and slot ID from the host equipment and allows tracking the up-stream processes. Since each contamination has specific origins, having wafer specific information can give important clues to discover the source of the contamination and identify the previous process fault.

Figure 4 shows some actual wafer outgassing with a variety of different contaminants. These different contamination events are associated with up-stream process faults. For example, the photoresist contamination may be caused by incomplete PR

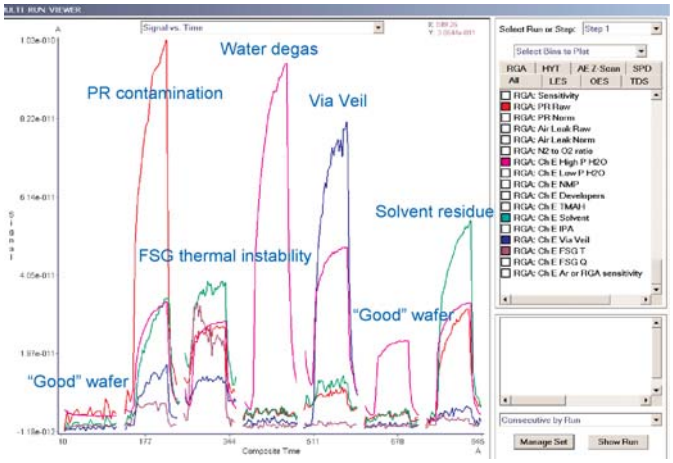

Figure 4 - Identifying different contaminations on the wafer by IPM.

removal during PR ashing and stripping or via Veil residues which are the result of poor wafer cleaning. The high water residue on the wafer may be caused by a poor rinse and dry process. Catching these events quickly on the degas chamber can significantly reduce their impact on down-stream processes and wafer yields. It can also help to optimize the up-stream processes and thus provide integrated information for process control.

PR Detection

A wafer contaminated with photoresist can be incidentally introduced into a PVD cluster tool by either an incomplete ash or inadvertently missed steps of the photoresist strip. When this occurs, it is important to stop the wafer at the degas chamber before it reaches the PVD process chambers. Subsequent wafers will remain safe if they are prohibited from entering the tool. The Transpector CPM IPM system continuously monitors the degas cycle in real time, looks for organic compounds that correspond to photoresist and compares them to the PR signal that was either defined based on the universal PR used in the industry or by customer specific PR compounds. Once these compounds are identified and reach certain PR alarm setpoints, the Transpector CPM IPM system can generate an alarm and send a stop-processing signal to the tool controller or automatically interrupt the processing of any wafer.

Figure 5 shows four wafers, including a PR contaminated wafer, run through the degas process. The first and fourth dummy wafers show a typical signature where small amounts of water vapor outgas in both high pressure degas and pumpdown state. The second wafer is contaminated by 5% PR leftover and has a red alarm. Its PR signal bin (red color) increases more than a decade compared to the first dummy wafer. The third wafer, 2nd degas for the 5% PR wafer, has a yellow alarm because either there is a small amount of PR leftover on the wafer or the chamber was contaminated after running photoresist contamination wafer. The alarm limit or sensitivity can be adjusted to match the conditions of the product and process tool. Because wafer heating and degassing continues to occur even as the chamber is being pumped out for wafer transfer, the wafer is still outgassing and experiencing PR pyrolysis. As discussed above, the Transpector CPM IPM System supplies a high conductance sampling valve which allows it to detect the PR in the pumping and base pressure state and thus provides additional photoresist contamination information.

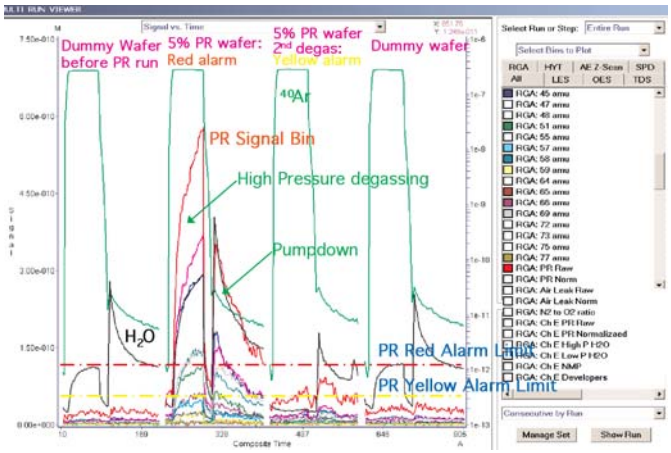

Figure 5 - Photoresist detection with IPM.

PROCESS CONTROL

Since the INFICON Transpector CPM IPM System monitors every wafer degas cycle, the PR or other previous process fault detection was achieved in real time. Once any excursion events were detected, based on the event criticality, a warning or alarm message can be sent to the production tool or generate a stop production tool signal. For example, a PR alarm message would actually prevent further wafer transfer upon all chambers' process completion. The PR contaminated wafer is stopped in the degas chamber before it reaches the back end of the tool (process chambers). Subsequent wafers will remain safe if they are prohibited from entering the tool. The Transpector CPM IPM System can also send this instant message to engineers by email, page or office computers.

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