INFICON

APPLICATION NOTE

ENDPOINT DETECTION FOR CHAMBER CLEAN

Novellus SPEED Nitride CVD

The chemical vapor deposition (CVD) process requires periodic cleaning of the chamber walls to prevent flaking of the film that builds on the walls during the deposition process. This chamber cleaning is accomplished using a radio-frequency plasma and florinated reactive gases. Since the chamber walls are typically made of aluminum, it is critical to stop the cleaning process before the reactive gases attack the walls and process kit. It is common practice to stop the chamber clean based on a time calculated from the deposited film thickness and an expected film etch rate during the plasma clean. Typically, the film accumulation value stored in the tool is an inaccurate approximation due to non-uniformity of the film deposited on the chamber wall. The etch rate used in the calculation is not tested very often, and may drift over time. These inaccuracies in etch rate and film thickness cause both under-clean, when the etch time is not long enough leaving film still on the chamber, and over-clean, when the etch time is too long and the chamber walls are etched by the plasma. A non-optimized clean time on a CVD chamber creates elevated defect density on wafers processed following the clean. Over-clean creates aluminum fluoride (AlF) particles, whereas under-clean results in nitride or oxide flakes on the wafers.

The Stiletto® *in situ* particle monitoring system can be used to detect endpoint for CVD chamber cleans. Stiletto monitors particle counts during the clean, as the film is flaking off the chamber wall. The particle count profile decreases as the amount of deposition on the wall reduces. Endpoint is determined when the particle count remains at zero for a given time period. The Stiletto sensor provides direct measurement of chamber wall condition, and therefore it is a robust tool for preventing over-cleaning and under-cleaning on CVD chambers.

SYSTEM CONFIGURATION

The Stiletto sensor can be installed on the Novellus Concept 2 SPEED High Density Plasma (HDP) CVD Chamber, as shown in Figure 1. There are three pumping ports on the SPEED chamber. Two of these ports are connected to large turbo pumps for the deposition process. Between the turbo pump ports there is a clean port, which is used during the plasma cleans. Stiletto is installed in the clean port foreline and monitors particles that flow down the pipe as the chamber is cleaned.

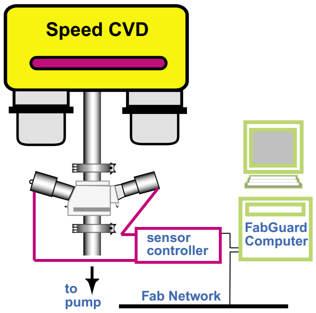


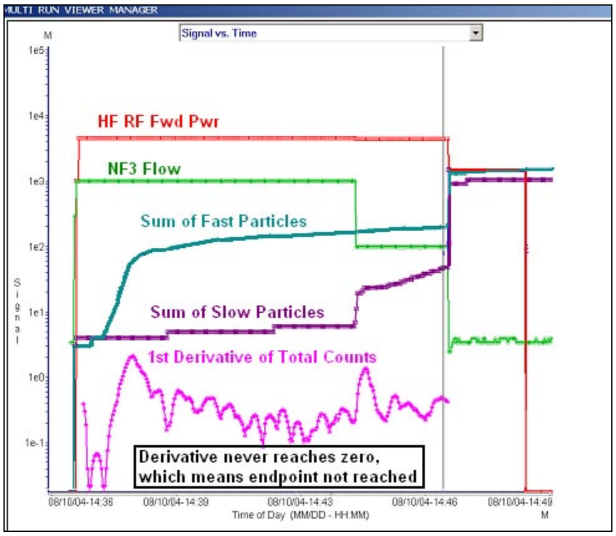
Figure 1 - Stiletto installation on SPEED clean port

DATA ACQUISITION AND ENDPOINT ANALYSIS

FabGuard® Sensor Integration and Analysis System acquires data from both Stiletto and the SPEED tool. FabGuard collects Stiletto data through TCP/IP and is integrated to the tool via RS232 SECS protocol. Data acquisition begins as soon as the clean recipe starts and ends when the clean recipe has stopped. Based on Stiletto data and tool parameters, FabGuard optimizes the endpoint using Logic Analysis. The following list includes Signal Bins and Logic Analysis that are used for this application.

- Total Counts (Σ all particle counts)
- 1st derivative of the Total Counts
- Endpoint Time (time to reach endpoint)
- Evaluation (Clean Time – Endpoint Time)

The basic idea of endpoint detection using the *in situ* particle sensor is to monitor the rate of particle generation from the cleaning process. Assuming that all particles come from the nitride deposition on the chamber wall and internal parts, the total particle count represents the amount of deposition on the wall, therefore, clean endpoint can be defined as the time when the rate of total counts approaches zero as shown in Figure 2.



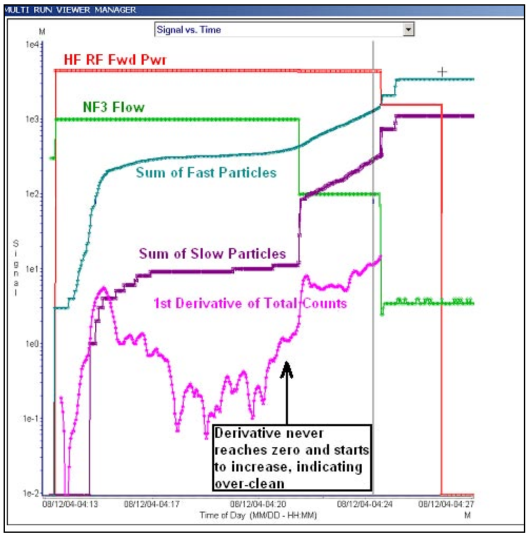
Derivative never reaches zero, which means endpoint not reached

Figure 2 - Stiletto data from SPEED showing a clean that never reaches endpoint, under-clean.

As soon as endpoint conditions are met, FabGuard automatically calculates endpoint time and stores the value with each run as well as in the database. For evaluation purposes, the endpoint time can be plotted against the total clean time to understand the performance of each clean recipe. FabGuard can be configured to alarm under-clean or over-clean conditions, both of which can increase the number of defects in successive depositions on product wafers.

A run is considered under-cleaned when endpoint has never been reached, i.e., the rate of particle count has never reached zero. Under-clean condition leaves nitride film on the chamber wall, which may flake off during the next deposition. Figure 2 illustrates an under-clean data profile.

An over-clean condition occurs when the total count rate increases toward the end of the clean recipe. The sudden change in count rate represents a different reaction that generates particles. The accelerated count rate characterizes the reaction between fluorine radicals and aluminum parts in the chamber. This reaction creates aluminum-fluoride particles, which changes the surface of the chamber walls causing film adhesion problems during successive depositions. Figure 3 shows an over-clean condition represented by Stiletto data.



Derivative never reaches zero and starts to increase, indicating over-clean

Figure 3 - Stiletto data from SPEED clean showing increased counts indicating over-clean.

CONCLUSION

The Stiletto *in situ* particle sensor can be used for clean endpoint detection and optimization on the Novellus Concept 2 SPEED chamber. It is a direct measurement of the amount of deposited film flaking off the chamber wall and other internal parts. FabGuard uses the rate of total particle counts to determine the endpoint in real time and store the endpoint time on each run. The endpoint time can be use to evaluate the performance of the clean recipe by determining whether the chamber was under- or over-cleaned. Ultimately, clean time optimization improves overall yield by reducing defect density caused by leftover film on the chamber wall and subsequently reduces tool down time related to particle excursions. Stiletto can be used to detect both under- and over-clean conditions in real time, which can be used to indicate that chamber conditioning is needed or further cleaning might be required prior to running any product wafers.

STILETTO MONITORING CAPABILITIES

- Fully automated operation
- Particle detection and sizing
- Monitors efficiency of plasma clean
- Utilize as an endpoint detector
- Alarms on faulty chamber clean
- Detects over-, under-cleaning of chamber
- Minimizes yield loss with real-time control

INFICON Instruments for Intelligent Control™

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