SOLUTIONS IN SEMICONDUCTOR PROCESS

Endpoint Detection in Chamber Clean

MKS NDIR Analyzers offer powerful solutions for highly accurate chamber clean end point detection

Introduction

Chemical Vapor Deposition (CVD) is a chemical process in which volatile precursors react with a substrate resulting in the deposition of a conformal material film onto the substrate. These films include materials such as polysilicon, silicon dioxide, silicon nitride, and other silicon based material. CVD results in very uniform deposited films not just on the substrate, but also on the chamber surfaces.

Over time, unwanted deposition build-up on chamber surfaces leads to particulates and potential contamination, negatively impacting wafer yield. In order to reduce particulates stemming from chamber wall deposition, chambers must be cleaned periodically to remove build up. Removal of chamber deposition is achieved through introduction of reactive gas such as radical fluorine which reacts with surface films to generate silicon tetrafluoride (SiF_4) which is then removed from the chamber. The optimum clean time for a given chamber is a complex function of a number of variables including thickness of the deposited material, temperature, pressure, reactive gas delivery and material chemical composition.

MKS products solve key challenges for End Point Detection in Chamber Clean

- Fast response, real-time active chamber clean measurement
- Optimizing chamber clean time increases tool availability
- Reducing clean time, saving costs and increasing yield

Challenges in Endpoint Detection

Traditional chamber clean is a time based process. Due to the complexity of the chamber environment, a uniform time cannot address all chamber cleaning requirements. In fact, a single clean time for a given chamber is subject to change over time as etch rate variables may change or drift.

Most time-based processes are designed to over-etch in order to ensure total removal of CVD film across multiple chambers and tools. Over-etching results in reduced wafer throughput, excess use of reactive gas, and possible damage to chamber walls. Conversely, under-etching results in deposition film build up over time, leading to particulates. This will ultimately result in lower product yield.

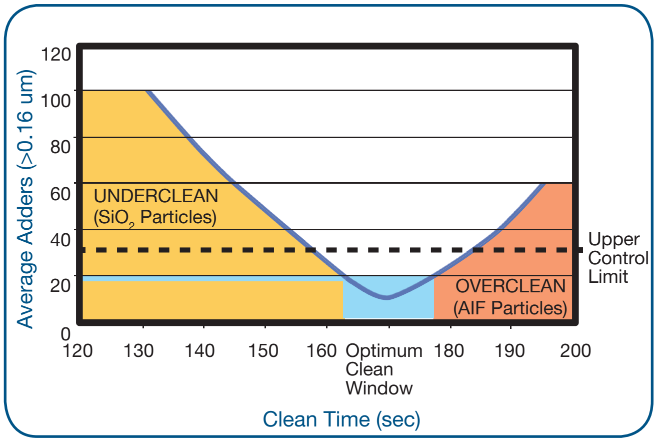

Figure 1- Particle count versus clean time for a given process.

Endpoint Detection in Chamber Clean

MKS Solutions

Optimal chamber clean can be established by direct measurement of SiF_4 formation. This dynamic approach provides a consistent level of chamber clean, eliminating the uncertainty of the time-based method. Additionally, active chamber clean measurement can result in cost savings, reducing clean time, gas usage, and increasing chamber longevity.

The MKS Process Sense™ endpoint sensor monitors the chamber clean process in real time using NDIR (non-dispersive infrared) technology. This low cost sensor is designed to mount on foreline exhaust for measurement of upstream chamber silicon content. Consequently, it can be incorporated into any silicon etch process. As the chamber is cleaned, the rate of SiF_4 creation decreases relative the level at clean initiation. Endpoint is established by monitoring the decreasing SiF_4 concentration (Figure 2). While chamber clean can vary based on complex environmental factors, the Process Sense analyzer's adaptive measurement approach accounts for all possible drift conditions in the chamber clean process ensuring optimal clean.

While traditional time-based over-etch consumes excess time and process gas, the Process Sense analyzer ensures the most efficient and cost effective clean. Table 1 provides an example of the savings attributed to a Process Sense analyzer monitored chamber clean process. The savings of this real world chamber clean example provide payback for the sensor in just a few months.

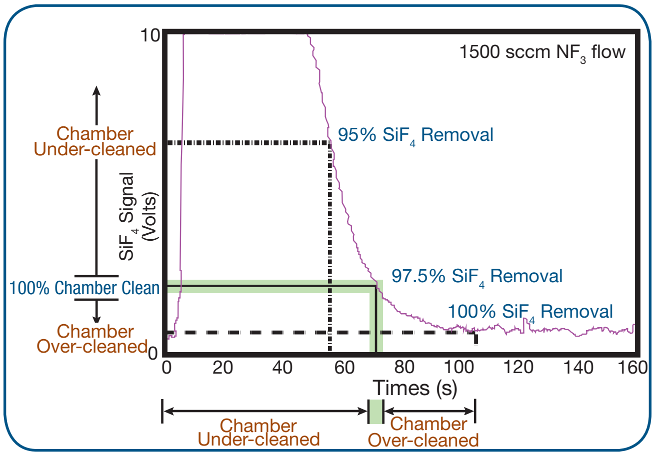

Figure 2 - Process Sense ensures the most efficient and cost effective chamber clean.

Process:	**USG 8k-3x cln**
Current clean time (sec)	170
Current clean time per wafer (sec)	57
Expected average clean time with Endpoint (sec)	155
Expected average clean time per wafer with Endpoint (sec)	52
Expected average clean time reduction per wafer with Endpoint (sec)	5 secs
NF_3 saving per wafer per chamber assuming 1500 sccm flow rate (scc)	125
NF_3 cost savings per wafer assuming $1.00/lit ($/wafer)	12.5 cents
NF_3 cost savings per chamber per year	$10,173
NF_3 cost (3-ch) savings per system per year	$30.519

Table 1 – Typical cost savings example of Process Sense monitored chamber clean.

To control process inputs during deposition, MKS also offers a module based control system that can handle multiple inputs such as temperature and pressure, and supports several operating systems including real time OS (RTOS) and Linux. With an excellent GUI interface, programming of the control system is quick, and easy.

MKS is the leader in critical subsystems for semiconductor fabrication. We work closely with our customers to help solve their most challenging endpoint and deposition problems, leveraging our technical innovation, experience and passion.