

Sensors for Improved Wafer Yield

MKS has a wide selection of process gas and instrument solutions powerful enough to ensure excellent tool optimization in Semi Fab Chambers.

Introduction

Semiconductor manufacturing is a complex and intricate series of processes, including the critical processes of deposition and etch. During deposition, a thin film of material is deposited onto the wafer surface using a variety of deposition processes including physical and chemical based processes. Etch removes blanket or patterned film to create the circuit. Various deposition and etch processes have unique chemistries determined by precursor materials and delivery parameters, and are governed by the control of the chamber environment.

These unique chemistries are employed to produce a variety of by-products which achieve the desired deposition and etch results. The chemistry, delivery

parameters and chamber conditions may be measured to provide valuable insight to optimize the process and identify process completion. Currently, many of these process steps are carried out on a timed basis, without considering unreacted precursor or generation of by-product. Time based completion processes lead not only to wasted precursor materials, but also to reduced process precision and reduced overall chamber efficiency, immediately or over time. Manufacturing speed, process reproducibility, and overall efficiency of these processes becomes more critical as capability, volume demand, and electronic devices yield continues to grow.

MKS products solve key critical Wafer Process Characterization and Performance Validation challenges with solutions in:

- Gas Analysis
- Plasma
- Pressure Control
- Flow
- Custom Vacuum
- Automation
- Process Monitoring

Challenges in Wafer Yield

As electronic devices such as phones and tablets continue to become smaller and faster with longer battery life, new techniques in wafer fabrication will continue to grow in complexity. New chemistries present new challenges in maintaining yield while improving productivity. Traditionally, process times were determined empirically based on the completion time required for the slowest performing chamber. This approach ensured all chambers reached completion. This non-optimal approach resulted in tool to tool variability, wasted precursor material and reduced wafer throughput. The process can be optimized and

chambers can be better matched by accurately measuring precursor and by-product gases for concentration and composition. Utilizing these approaches, less precursor gas is wasted realizing immediate return on investment. In addition to cost savings, minimizing spent precursor gas and eliminating excess precursor gas reduces any negative yield impact from undesired reactions. Additionally, detection of by-product gases through recombination or wall effects, enables immediate determination of process chemistry completion, increasing overall wafer throughput.

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MKS Solutions

Infrared Optical Sensors

MKS offers low cost, in situ, optical sensor solutions for measuring critical components in semiconductor process chamber chemistries. The flexibility of the low cost MKS non-dispersive infrared (NDIR) and tunable filter spectrometer (TFS) platforms allow customized solutions specifically for a wide variety of process chemistries. Sensor adaptation is made possible through process characterization with the MKS MultiGas™ Fourier transform infrared (FTIR) spectrometers. The MultiGas FTIR is capable of measuring all IR-active gases quickly (up to 5 Hz) and accurately ($\pm 2\%$). Once equipped in-line with the chamber exhaust, the MultiGas FTIR measurements may be used to identify and quantify compounds of interest in real time. These compounds may then be assessed for use as process indicators. Other MKS sensors, such as the MKS Process Sense™ NDIR and Precise™ TFS™ can be configured to detect compounds of interest and indicate process step transitions. MKS sensors may then be coupled to an array of other MKS instruments, software and controls to seamlessly and accurately allow the semi fab to control the process to reduce defects providing immediate return on investment and improved yield.

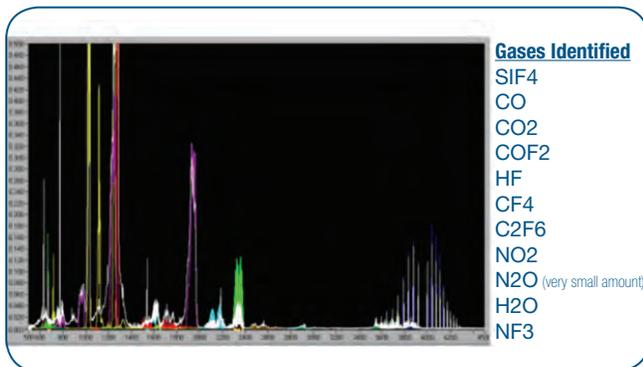


Figure A: Chamber clean exhaust chemistry measured by MKS MultiGas™ FTIR

Gas Flow and Delivery

MKS' flow products includes mass flow controllers (MFC), in-situ mass flow verifiers, and flow ratio controllers which accurately and repeatably divide gas flows into precise streams to multiple points in the process and provide repeatable gas doses into the recipe.

Pressure Measurement and Control

Dynamic pressure control provides the best opportunity to achieve consistent and stable vacuum conditions. To achieve this balance MKS' world leading Baratron® capacitance manometers, flow control, valves and Granville-Phillips® gauges are used to accurately and reliably control process pressure.

Plasma Sources

MKS pioneered remote plasma sources for chamber cleaning and is the leading supplier of plasma sources for process chamber clean. Additionally, the MKS Process Sense, an FTIR based endpoint detector optimizes chamber cleaning and monitors effluent gases.

Process Monitoring

MKS Residual Gas Analyzers, or RGAs, are used for process monitoring by analyzing the partial pressures of vacuum residuals, and providing endpoint detection. MKS RGAs provide the highest sensitivity measurements of the gas species present in a vacuum, have robust sensors that keep working even in harsh process environments, and acquire the highest quality of data at the fastest possible speeds.

Automation and Control

To ensure comprehensive process control, the MKS Automation Platform can be configured for use in many applications—from those requiring simple I/O or other control networks all the way up to a fully programmable controller, seamlessly connecting to MKS data analytics and other MKS products or manufacturers.

Vacuum Integrity & Custom Vacuum

MKS offers vacuum quality instruments to detect vacuum leaks and monitor the composition of the gases in the process chamber. MKS Custom Vacuum Solutions offers state-of-the-art machining, welding, finishing and cleaning, as well as subassembly, assembly and system testing of components, to UHV standards. MKS provides expert engineering, custom subcontract manufacturing and focused project management ensuring reliable, high quality vacuum solutions.

MKS Instruments broad portfolio of product solutions provides better yield and with higher productivity. Leverage MKS' technical innovation, experience and passion to solve your most challenging problems in wafer yield.