ATONARP ASTON™

Equipment & Process Co-Optimization
Application Brief

Equipment Process Co-optimization (EPCO): A $38B Manufacturing Optimization Opportunity

Advanced processes now require Equipment and Process Co-Optimization (EPCO). A 2021 paper by McKinsey & Co. demonstrated that semiconductor manufacturing optimization, using artificial intelligence (AI) & machine learning (ML), represents a $38B cost saving opportunity through improved yields and increased throughput.

McKinsey highlighted the single biggest intervention point to help companies realize these benefits is adjustment of tool parameters, using live tool sensor data from current and previous steps to enable AI/ML algorithms to optimize the nonlinear relationship between process operations.

Key to successful AI/ML deployment is actionable real-time data. Aston in-situ real-time molecular diagnostics and its cloud connected data are key technologies enabling this capability to unlock the potential for semiconductor EPCO.

The Problem

As process nodes have shrunk, new variables have emerged that affect process yield, challenging the established *Copy Exactly!* methodologies. Some of these critical variables that can affect process performance include localized virtual vacuum leaks, subtle reaction gas partial pressure variations, wafer surface saturation due to changes in pumping performance, surface reactivity due to changing wafer temperature, chamber clean end point, and chamber seasoning profile.

Additional challenges such as inter-layer adhesion, 300mm wafer mechanical stresses, new atomic level deposition and etch chemistries, exotic low resistance contact and fill metals, stringent cross contamination protocols and maximizing throughput all require greater insight to how the process and equipment are interacting. Optimizing advanced processes such as these now demand higher accuracy metrology tools and add a new layer of in-situ molecular complexity to the *Copy Exactly!* methodology protocols.

Aston Benefits

- Corrosive Gas Resistant
- Deposition Gas Resistant
- Real Time, Actionable Data
- Cloud Connectivity Ready
- No Plasma Required
- Best-in-Class Features
  - Stability
  - Repeatability
  - Sensor Lifetime
  - Mass Range
  - Resolution
  - Min Detectable (PP)
  - Sensitivity (PPB)
  - Sample Rate

Applications Supported

- Dielectric Etch
- Metal Etch EPD
- CVD Monitoring
- Chamber Clean EPD
- Chamber Fingerprinting
- Chamber Matching
- HAR etch
- Small open area <0.3% etch
- ALD
- ALE

ATONARP
ASTON™

The Solution

In-Situ, Real-Time Data

There are three main types of data in the semiconductor process control FAB environment:

1. In-Situ data taken real time on the process tool
2. In-line data to measure results (usually immediately) after a processing step
3. Parametric or post-Fab data (used for wafer line yield and wafer ship acceptance criteria)

Additionally, these three main data can be further categorized into three sub-types

1. Target Data i.e., what the tool was targeting as part of the recipe e.g., target temperature: **327 °C**, target SiF_4 molar concentration: **100 mol/l**
2. Measured Data i.e., what is measured at a given instance e.g., measured temperature **9 °C**, actual CF_4 molar concentration: **0.097 mol/l**
3. Informational Data i.e., wafer lot number: **8F2342G,** equipment serial number & chamber: **32FF4567-4**

Measuring in-situ, real-time data at the molecular level gives true insight to how the process is setup and proceeding, offering rich, actionable, and impactful data. Reactants, by-products, and partial pressure concentrations can be identified and quantified, allowing for dynamic process control to ensure tight mean and standard deviation control for a given process module across run-to-run, chamber-to-chamber, tool-to-tool, and even site-to-site. Managing overall complex semiconductor process control and line-yield starts with having tight control on individual process steps and ensuring low variability and tight statistical process control (SPC).

Summary

Aston from Atonarp was designed from the ground up to meet the needs of in-situ molecular analysis to enable EPC0. The advanced performance benefits available with Aston's robust, real-time, in-situ molecular sensor solutions are many, including:

- Accurate real-time based end point detection
- Run-to-run and real time EPC0
- Parameter adjustments
- Machine learning, artificial intelligence,
- Process statistical process control and deviation identification
- Line yield root-cause analysis
- Optimized preventative maintenance
- Tracking to a golden tool or process