TECHNICAL PAPER

# Multipoint Sampling for AMC Monitoring

Version 01. Rev 01.

LIGHTHOUSE
WORLDWIDE SOLUTIONS

# Multipoint Sampling for AMC Monitoring

*by Peter Maguire, VP of Sales-Asia Pacific, Lighthouse Worldwide Solutions*

Monitoring for any type of contamination is an important aspect of contamination control. Monitoring specifically for AMC is important in industries where AMC can directly affect the product or process.

Airborne Molecular Contamination (AMC) is chemical contamination in the form of vapors or aerosols that have a detrimental effect on a product or a process. These chemicals may be organic or inorganic in nature and include acids, bases, polymer additives, organometallic compounds and dopants. The main sources of AMC are building and cleanroom construction materials, general environment, process chemicals and operating personnel.

AMC can cause a multitude of adverse effects, such as:

- Corrosion on metal surfaces on the wafer
- Degradation of HEPA/ULPA filter media
- Haze on wafers
- Haze on optics
- T Topping of chemically amplified photo resist
- Voltage shifts and changes in contact resistance.

Even the newest state of the art facilities are not immune from AMC related incidents. Incidents such as spills or contamination episodes result from tool or equipment failures and associated maintenance. Chemical filtration is affected by the environment; changes in the environment may result in performance changes in chemical filtration. Only continuous AMC monitoring can provide assurance that the facility is performing properly and can alert personnel when an incident has occurred. With this type of monitoring, responses to incidents can be carried out immediately instead of days or weeks after the facility has been contaminated.

Each step in the manufacturing process is sensitive to different types and levels of AMC. The most common chemicals to be monitored in a semiconductor facility are:

- Ammonia
- NMP
- Total Amines
- Total Acids
- Total Sulfur
- H2S
- HF
- HCL

In general, the detection limits of online instruments should reach into the low ppb level and, in some cases, ppt levels are required.

The cost to place an online chemical sensor in every location that should be monitored would be cost prohibitive. For this reason, the implementation of a multipoint AMC sampling system can reduce the cost per sample point while allowing the facility to achieve the goal of online monitoring. This document discusses the necessary steps to take in implementing an online AMC monitoring system:

1. Understand which process steps are most sensitive to molecular contamination in general.
2. Find the specific molecular contamination to which the processes are sensitive.
3. Determine the products' levels of sensitivity to the target chemicals.

The best source of information about which process steps to monitor will come from the process departments themselves. They should be able to provide some indication of what chemicals are critical to monitor and at what levels they should be monitored. One of the most common processes monitored in the semiconductor manufacturing cycle is the photolithography process.

Trace levels of Ammonia and or NMP can cause T Topping on the wafer surface. Hydrocarbons can become deposited onto the optical surfaces used inside the stepper or scanner, forming a haze over the lens. Typical

control levels for Ammonia are 1 ppb or less.

Once you have determined the process to monitor, the chemicals to monitor and the level at which you want to monitor, the next stage is to identify the instrumentation that will work for the application. When evaluating different analyzers, there are several factors to consider:

- Target Chemical
- Detection Limits
- Dynamic Range
- Response Time
- Zero and Span drift
- Potential Interference
- Calibration Method
- Operation Cost

**Target Chemical**

Some analyzers are able to analyze multiple types of chemicals, while others can analyze only one specific chemical. In general, a detection limit of 1 ppb or less requires the use of an analyzer that targets only one chemical.

**Detection Limit**

As a rule of thumb, the detection limit of the instrument should be, at most, half of what the maximum allowable limit is for the chemical you want to monitor. For example, in the case of Ammonia, if the maximum allowable concentration is 1ppb then you should use an analyzer with a detection limit of 0.5 ppb. This will give you enough headroom to ensure your analyzer is providing accurate data.

**Dynamic Range**

The minimum and maximum concentration levels the analyzer can monitor determine the dynamic range of the analyzer. It is important to use an analyzer with as large a dynamic range as possible so that if a major event occurs, the actual peak of the event can be determined.

**Response Time**

The response time of the analyzer is the time is takes to adjust from one fixed concentration level to another. In most cases, an analyzer's response time is listed as a percentage of the change in chemical concentration that the analyzer can display within a fixed amount of time. For example, if an analyzer has a response time specification of 90% in 60 seconds this means that within 60 seconds of a change in concentration, the analyzer will be able to display 90% of the new concentration level. The target is to choose an analyzer with a fast enough response time so that, in environments where concentrations change frequently, peaks and valleys will not be missed.

**Zero and Span Drift**

The analyzer's zero and span drift are important to understand because ultimately they determine how often you will need to calibrate the instrument. For example, if your control limit is 1 ppb and the analyzer you purchase has a zero and/or span drift of 0.1 ppb per day then in a worst case scenario you will need to have the analyzer calibrated once every 10 days

**Potential Cross Interferences**

Almost all analyzers are susceptible to some type of cross interference from other types of chemicals. It is important to determine what the potential interferences are, to see if the analyzer can be used in the specific location you want to monitor. The type of cross interference to which an analyzer will be susceptible is based on the analyzing technology of the instrument and what steps the sensor manufacturer has taken to minimize cross interference.

### Calibration Method

To target is to purchase an analyzer that is easily calibrated without support from the supplier. Although some analyzers have built in calibration standards, most require external fixed concentration gas samples for span calibration and $N_2$ or CDA for calibrating the zero point.

### Operation Cost

Most analyzers require some type of monthly, quarterly and or yearly maintenance. This maintenance normally consists of calibration and parts replacement. When purchasing an analyzer, make sure to request a quote that also includes the cost of regular maintenance of the analyzer.

Once you have selected your analyzers, the next step is to determine the type of sampling system you want to use. The sampling system is what will allow you to sample from multiple locations using a single analyzer. Here are a few things to consider when selecting a sampling unit:

- Number of locations you want to sample
- Sample and Purge Flow
- Accessibility of the data
- Connectivity of the analyzer to the sampling system
- Connectivity of the sampling system to an external data logger or monitoring system

The number of sample locations to monitor is the first thing you must decide. This decision may be made based on the acceptable amount of time between samples at any one location. When calculating this time, you must consider both the sample and purge times. For example, if the sample time is 15 minutes and the purge time is 5 minutes, then each sample will take 20 minutes to complete. If you have 16 locations, the sample cycle time would be (16 x 20) / 60 = 5.33. This means it will take 5 hours and 20 minutes to complete a sample sequence.

### Sample and Purge Flow

The amount of sample airflow is important because it will determine the number of sensors that can be connected to the sampling system. For example, if the sample flow is 3 liters per minute and the analyzer you are using requires 1.5 liters of air per minute, then you can only connect 2 analyzers to the sampling unit before you would run out of sample air. In general, you want the highest sample flow possible.

Regarding purge flow, make sure the sampling system allows for constant purge flow though all sample points that are not currently being sampled. This ensures that a fresh sample is always in the sample tube and that the air in the sample tube does not become stagnant. Purge flow should be a minimum of 10 liters per minute through each tube at the same time.

### Accessibility of the Data

The decision must be made whether you want the collected data to be accessible at the sampling unit. In most cases, it is recommended that at least some current and historical data is made available. That way, trends can be viewed directly in the cleanroom without having to exit to another location where the data is being held for long-term analysis. Data can be made accessible via a local LCD screen and a simple interface.

For long-term analysis, the collected data should be stored in a database where it can be accessed when needed.

### Connectivity of the Analyzer to the Sampling System

The sampling system should be able to collect data from different types of analyzers with different signal outputs. The most common types of signals that will come from an analyzer is as follows: 4 – 20mA, 0 – 5 volt, and Modbus. In some instances, an analyzer may have a proprietary signal output and, in this case, a driver would need to be written and installed on the sampling system before data can be collected from the analyzer. Since some companies will want to use multiple analyzers, it is important that the sampling system

can handle multiple simultaneous inputs. A minimum of three analogs and 1 Modbus input is recommended.

**Connectivity of the Sampling System to a Data Logger or Monitoring System**

The sampling system should be easily connectable to a data logger or online monitoring system for review of both current and historical data. It is best to find a sampling system that has a standard industry data output protocol so that it can be easily integrated into an existing online system.

The final stage is to pick specific sample locations in each process. Sample points should be installed as close to critical processes as possible without interfering with those processes. It is common to install points both inside and outside a process so that, if an increase in AMC does occur, it can be determined whether the increase came from the ambient environment or from within the tool itself.

It is also common to install sample points up and down stream from the chemical filters. This will help to understand the removal efficiency of the chemical filters.

Most companies will use Teflon tubing as the media for sampling the air. The length of the tubing from the sampling system to the sample point should be kept as short as possible. This reduces the chance for dilution or contamination of the sample air.

In summary, there are many steps that need to be taken to successfully implement an online AMC sampling system. First, a determination of what process steps need to be monitored and what chemicals in those steps should be monitored. Second is to identify an analyzer or analyzers that meet your requirements. Be sure and use the list of factors to consider, listed in the above section, when evaluating an analyzer. The sampling system itself must be selected and, finally, the exact sample locations must be chosen. By following the outline above, you will be on your way to implementing an effective online AMC monitoring system.

*Peter Maguire is Vice President for Sales-Asia Pacific at Lighthouse Worldwide Solutions (www.golighthouse.com), a particle counter systems manufacturer based in Fremont, CA. Lighthouse Worldwide Solutions specializes in facility monitoring systems and components for the Pharmaceutical, Semiconductor, and Disk Drive industries. He can be reached at peterm@golighthouse.com or (510) 438-0500.*