

# Contamination Management Solutions

Your solutions for airborne molecular contamination management and particle contamination monitoring

# Contamination Management

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## Contamination challenges

Are you struggling with contamination such as particles or molecules impacting your devices during manufacturing or storage operations? Then this brochure will give you an overview of how we can help you solve this issue.

## Our know-how

With more than 20 years of experience in contamination management, Pfeiffer Vacuum provides innovative monitoring and containment solutions that are used notably in the following fields of application:

- Microelectronics
- Optics
- Display manufacturing
- Photovoltaics
- Pharmaceutical industry

## Proven track record

All contamination management solutions have been qualified by technology leaders and have demonstrated quantified results such as:

- Yield enhancement
- Quality improvement
- Manufacturing flexibility



### Advantages

Our collaborative customer-oriented solutions are developed by a highly skilled team with worldwide knowledge and experience in contamination management. The innovative and high-performance equipment can be used from R&D to production.

All tools can easily be upgraded with the latest analyzers and particle counters.

### Metrology tools for semi fabs

#### Pod Analyzer – APA:

Unique solution to control airborne molecular contamination (AMC) in FOUPs<sup>1)</sup>

#### Dry Particle Counter – ADPC:

Unique solution to control particles in FOUPs<sup>1)</sup> and FOSBs<sup>2)</sup>

#### Ambient Multi Port Controlling – AMPC:

Innovative solution to control fab environment

### Wafer decontamination tool

#### Pod Regenerator – APR:

Unique solution to remove AMC and humidity from FOUPs<sup>1)</sup> and wafers

<sup>1)</sup> Front opening unified pod

<sup>2)</sup> Front Opening Shipping Box



Pod Analyzer –  
APA



Dry Particle Counter –  
ADPC



Ambient Multi Port  
Controlling – AMPC



Pod Regenerator –  
APR

# APA – Pod Analyzer

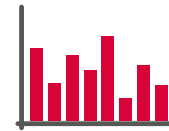
Airborne molecular contamination monitoring inside FOUPs in the semiconductor industry



High throughput



Your added value



A wide range of gas detection

## An innovative solution

Sub-ppbv levels of contamination such as acids or volatile organic compounds can degrade process performance. Fab airborne molecular contamination (AMC) requirements have been defined, but AMC at the equipment and FOUP level needs to be understood and defined as stated by the IRDS<sup>TM3)</sup>.

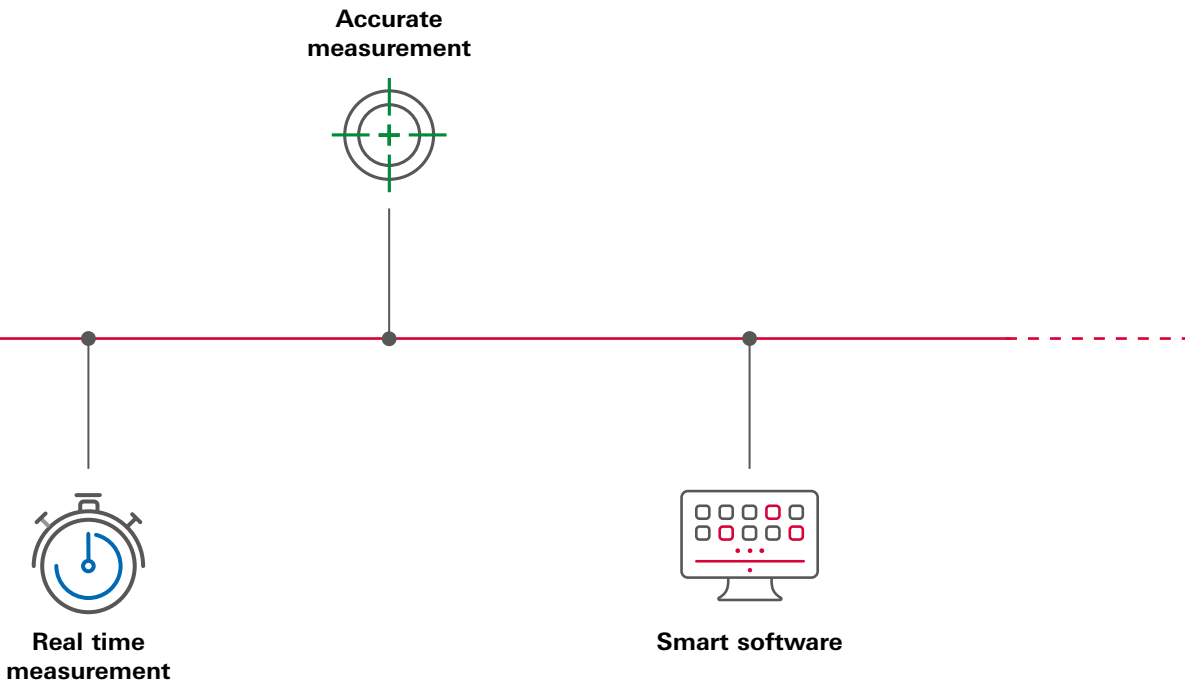
The APA 302 is a unique patented solution to monitor and track AMC in-FOUP with or without wafers in a production environment. The APA range can be considered as a technical platform offering different technologies for AMC monitoring.

## APA range options

The APA range includes various tools:

- APA 302 S (standard)
- APA 302 C (cabinet) the optional cabinet offers space for additional analyzers to increase compound monitoring
- APA 302 L (large) especially designed for semi fabs that wish to monitor a large variety of compounds
- APA 302 LF (LabinFab) to go deeper into molecule identification
- APA 302 LD for FOUP leak check monitoring

<sup>3)</sup> International Roadmap for Devices and Systems by the IEEE



### Advantages

- Small footprint under OHT<sup>4)</sup>
- No FOUP modification needed
- Throughput up to 16 FOUPs per hour with full automation
- Easy and Safe utilization
- High sensitivity
- SECS-GEM<sup>5)6)</sup> communication
- Threshold compounds management

### Process description

**Step 1:** FOUP sent to the Tool by OHT and automatically loaded onto the Tool

**Step 2:** FOUP monitoring

- Sampling through FOUP filter

**Step 3:** FOUP unloaded and collected by OHT

**Step 4:** Tool idle position, ambient monitoring

- Measurement is continuously performed when there is no FOUP in order to compare with cleanroom ambient

An automatic calibration routine is also possible and is defined depending on applications




<sup>4)</sup> Overhead Hoist Transportation

<sup>5)</sup> Semiconductor Equipment Communication Standard

<sup>6)</sup> Generic Equipment Model

# APA – Pod Analyzer

Airborne molecular contamination monitoring inside FOUPs in the semiconductor industry

Tool	APA 302 S	APA 302 C	APA 302 L
			
<b>Description</b>	<p>Equipped with two load ports, the APA 302 S is designed to track and monitor AMC in FOUP down to sub-ppbv levels. FOUP can be processed manually or automatically by semi fab automation. Measurements are displayed and stored for each FOUP locally. Threshold management can also be activated and sent to semi fab host.</p>	<p>This solution is specifically designed for semi fabs willing to add more analyzers for extra compound monitoring. The room available on this frame can manage up to eight extra analyzers.</p>	<p>APA 302 L is especially designed for semi fabs that wish to monitor a large variety of compounds. It offers a big capacity for analyzers storage.</p>
<b>Features</b>	<ul style="list-style-type: none"> <li>■ 26 U for analyzers</li> <li>■ Upgradeable tool: <b>Cabinet</b> and <b>LabinFab</b> options</li> </ul>	<ul style="list-style-type: none"> <li>■ 30 U for analyzers</li> <li>■ The cabinet option can be assembled onto existing APA 302 tools</li> <li>■ Can integrate a large portfolio of analyzers</li> </ul>	<ul style="list-style-type: none"> <li>■ 88 U for analyzers</li> <li>■ Could gather up to 20 analyzers</li> </ul>

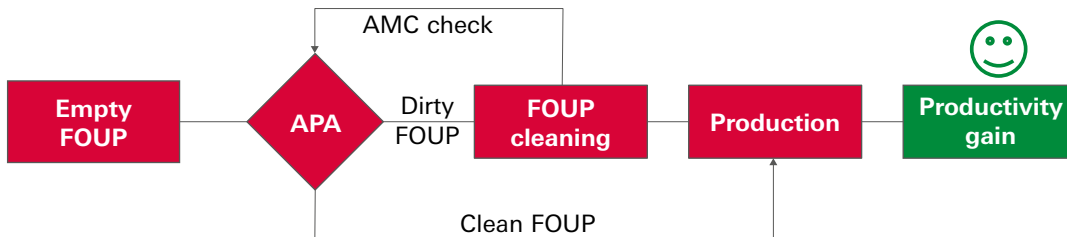
**Analyzers**

Compounds	Technology	Scale	Limit of detection	Size	Response time within 2 minutes
NH <sub>3</sub>	CRDS	0–10,000 ppbv	< 0.4 ppbv	4 U	> 80%
	IMS	0–50 (200) ppbv	< 0.2 ppbv	4 U	> 80%
Total amines	IMS	0–50 (200) ppbv	< 0.2 ppbv	4 U	> 80%
Total acids	IMS	0–200 ppbv	< 0.2 ppbv	4 U	> 90%
SO <sub>2</sub>	UV Fluorescence	0–500 ppbv	< 0.5 ppbv	4 U	> 80%
Sulfur	UV Fluorescence	0–500 ppbv	< 0.4 ppbv	4 U	> 80%
NO <sub>x</sub>	Chemiluminescence	0–500 ppbv	< 0.4 ppbv	4 U	> 80%
HCl	CRDS	0–2000 ppbv	0.1 ppbv	4 U	> 70%
HF	CRDS	0–1000 ppbv	0.1 ppbv	4 U	> 70%
H <sub>2</sub> O	Hygrometer	0–100% RH	5%	4 U	> 90%
AsH <sub>3</sub>	Electrochemical	18–200 ppbv	18 ppbv	4 U	> 90%
PH <sub>3</sub>	Electrochemical	110–1200 ppbv	110 ppbv	4 U	> 90%
Total VOC <sup>1)</sup>	FID	0–99 ppmv	20 ppbv	4 U	> 90%
VOC > 300 Organics	PTR – MS	< 0.1 ppbv	< 0.1 ppbv	23 U	

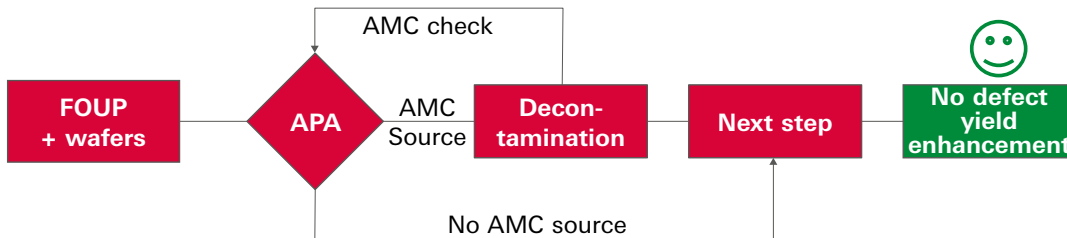
<sup>1)</sup> Volatile organic compounds

**Application examples**

**Productivity gain**



**Yield enhancement**



# APA 302 LF (LabInFab)

In-line FOUP monitoring and airborne molecular contamination tracking



Your added value

Automatic compound trapping systems



Production tool with R&D options

To go further in molecule identification, the APA 302 LF option enables the fab operator to safely trap FOUP and wafer contamination on site which can be analyzed in a second step with best-in-class instruments (chromatography etc.).

## FOUP measurement with standard recipe



## FOUP sampling with LabInFab recipe

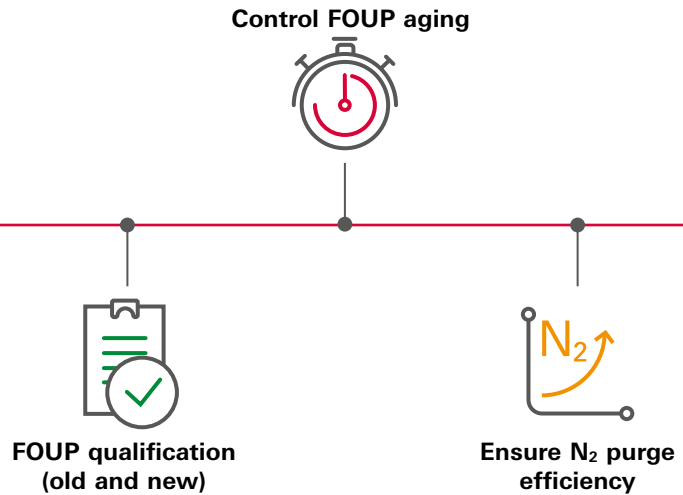




In-line-FOUP monitoring  
for leak detection tracking



Your added value



The APA 302 LD is an advanced platform that analyzes FOUF air tightness. As most advanced fabs use N<sub>2</sub> purge, the APA 302 LD can also ensure purge efficiency.

### APA LD features

- Space under OHT: 1,343 mm
- Conductance range:  
Low range recipe: 0.1 up to 5 l/s  
High range recipe: 1 up to 100 l/s
- High throughput up to 25 FOUFs per hour
- No FOUF modification needed
- SECS-GEM communication
- Threshold management

### Clean room FOUF contamination process



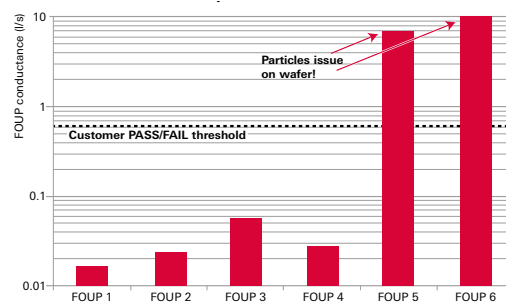
### Measurement principle

The conductance leakage of a FOUF door is linked to the pressure curve. The recipe is split into four steps.

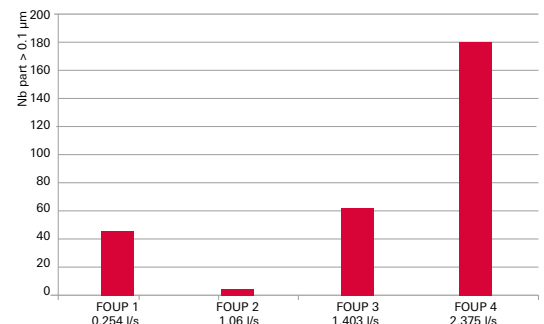
1. FOUF preparation
2. Pressure rise
3. Pressure analysis, data logging
4. Data post processing

### Results & applications

Evaluating and monitoring FOUF conductance (FOUF life time)

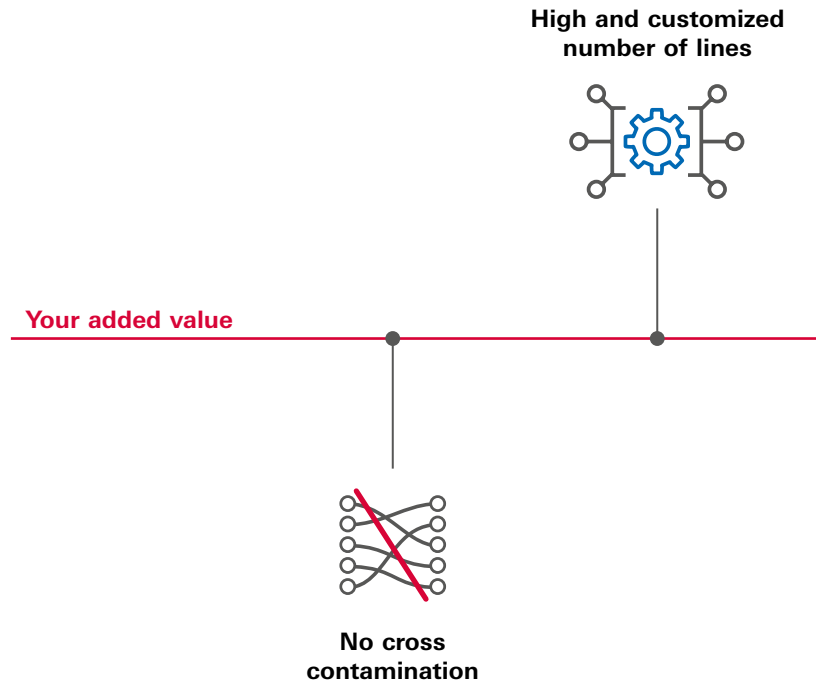


FOUF conductance and particle correlation



# AMPC – Ambient Multi Port Controlling

Clean room and equipment front end  
module monitoring



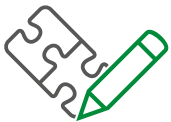
## **An innovative solution**

Airborne molecular contamination (AMC) in fabs is known as the major factor of yield loss. To control and understand where contamination comes from, Pfeiffer Vacuum offers a unique solution to monitor clean rooms as well as equipment front end module (EFEM) in the semiconductor market.

## **AMPC range features**

The AMPC range includes two tools: AMPC with a single frame and AMPC with an extension frame. A frame includes 39 U for extra analyzers. This can be used to upgrade existing AMPC units or directly added to new AMPC tools.

### Fast measurement and analysis



**A tailor made tool of high-end analyzers**



**Smart software**

#### **Advantages**

- Automatic system from 16 to 128 lines up to 200 meters
- Analyzing and cleaning within only 4 minutes depending on the required limit of detection
- Real time compound measurement
- Measurable compounds: organic and in-organic
- Analyzers from different trademark
- Possibility of upgrading the tool
- Cost benefit

# AMPC – Ambient Multi Port Controlling

Clean room and equipment front end  
module monitoring

## Process description

### Step 1: Continuous pumping

- All sampling tubes are always pumped down
- AMC is pulled out from the system

### Step 2: Deep conditioning

- Refreshment of a sampling tube by big pumping flow
- Sampling air is pulled into the analyzer

### Step 3: Measurement

- Sampling air is caught by analyzer pump
- Sampling air measurement in real time

### Step 4: Cleaning

- Purge of the system by air zero
- Cleaning in the system

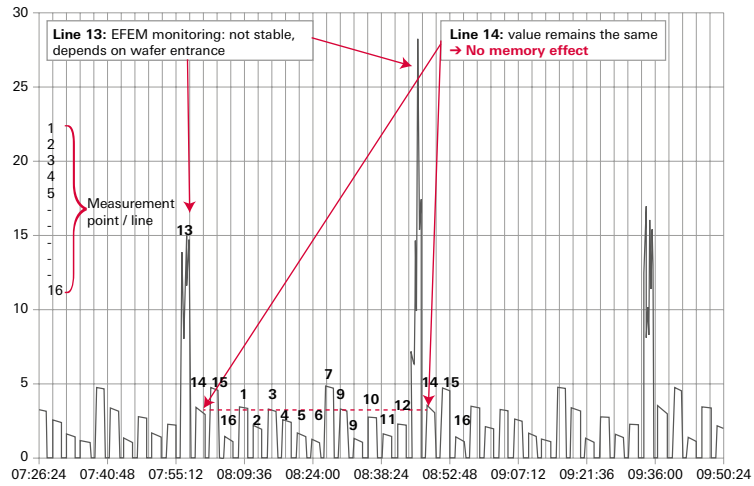
## Analyzers

The AMPC gathers the most advanced analyzers to detect and quantify acids, bases and organic compounds in up to 128 locations in a fab thanks to an innovative and integrated valves design.

Compounds	Technology	Scale	Limit of detection	Size
NH <sub>3</sub>	CRDS	0–10,000 ppb	0.4 ppb	4 U
HF	CRDS	0–500 ppb	0.1 ppb	4 U
HCl	CRDS	0–1,000 ppb	0.1 ppb	4 U
Total sulfur	UV fluorescent	0–1,000 ppb	0.4 ppb	4 U
Total acids	IMS	0–200 ppb	0.2 ppb	4 U
Total amines	IMS	0–200 ppbv	0.2 ppbv	4 U
Total VOC	FID	0–99 ppm	< 25 ppb	4 U
H <sub>2</sub> O	Hygrometer	0–100% RH	5 %	4 U
NO <sub>x</sub>	UV fluorescent	0–1,000 ppb	0.2 ppb	4 U
VOC	PTR–TOF MS	0–1,000 ppb	< 0.04 ppb (Toluene)	23 U

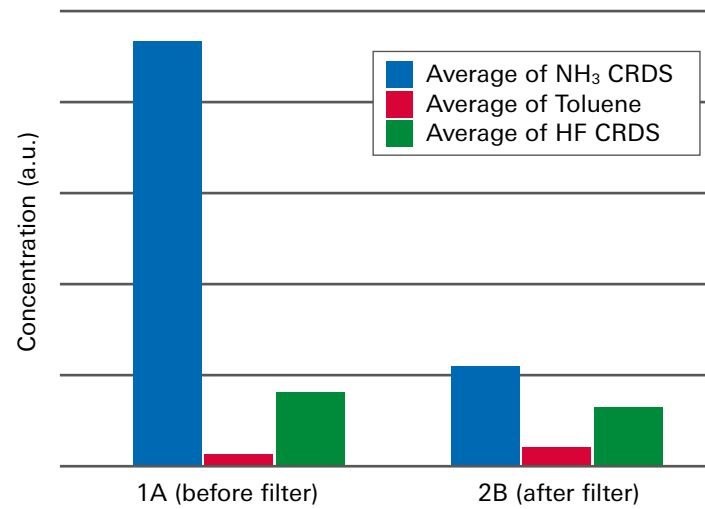
**Application examples**

**16 sampling lines compounds monitoring**



Tool used: AMPC  
 Compounds: Hydrogen fluorine  
 Benefit: No cross contamination

**Quality Control**



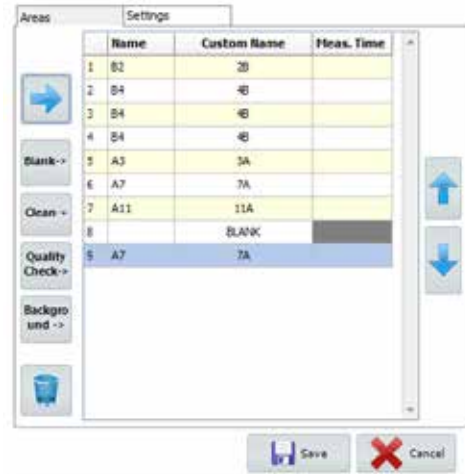
Tool used: AMPC  
 Compounds: All  
 Benefit: Optimized maintenance and cost reduction as filters will only be replaced when needed

# AMPC – Ambient Multi Port Controlling

Software and options

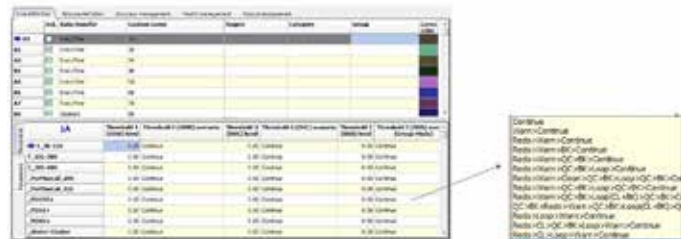
## Recipe

Chose the sampling lines to be monitored



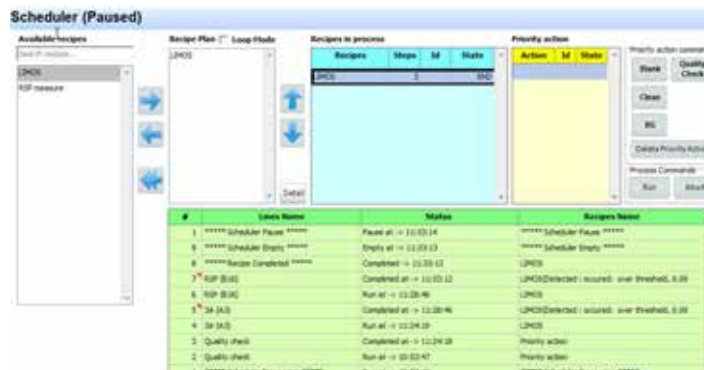
## Alarm and quality check management

Possibility to set different thresholds and alarms depending on the compounds for each sampling line. If an alarm is activated, the software allows to define specific actions: Repeat measurement, clean analyzer, make a blank, redefine new threshold.



## Scheduler

Manage automatically: Recipe/quality control/blank running. Possibility to cycle many recipes or the same recipes many times.



**Options**

**LabInFab - LF module**

The LabInFab module is used to sample within a Tenax tube or impinger for external analyzation. The objective of it is to find new molecules responsible of contamination. The LF rack is embedded as an analyzer within the AMPC module.

- A sampling rack with four impinger slots that can be removed to make the loading/unloading easier.
- In case of a significant drop in pressure levels, water traps will collect humidity to protect pump and analyzers.
- Front side warning lights to inform about the status of impingers.



LabInFab rack within the AMPC

**Canister and Canister Auto Sampler**

Canisters contain gases which are intended to be measured in airborne molecular contamination.

The Canister Auto Sampler is a cabinet dedicated to the storage of a large number of canisters.

- 15 storage positions
- Easy and safe canister connection
- Secure access to canisters (specific system of doors and exhausts)



Canister



Auto sampler concept

# ADPC 302 – Dry Particle Counter

Particle contamination monitoring  
inside FOUPs and FOSBs in the  
semiconductor industry



In-line  
measurement



Your added value



High level of  
precision

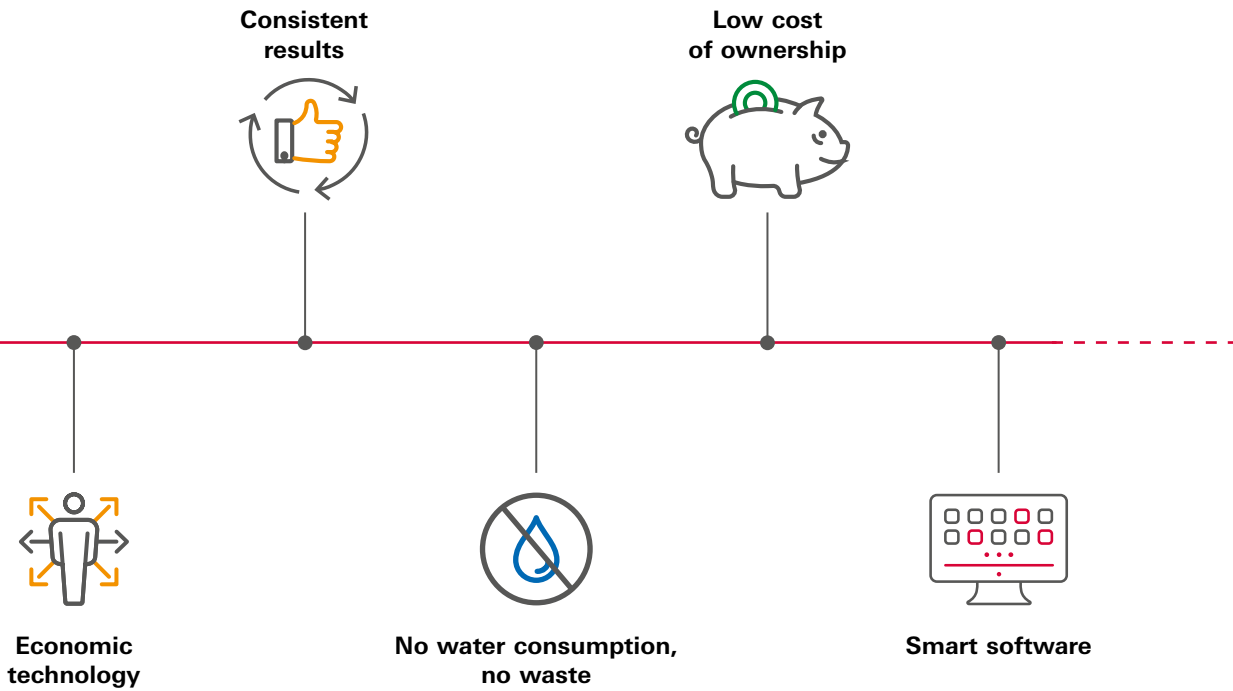
## An innovative solution

The ADPC 302 is the unique dry system for monitoring particle contamination inside transportation carriers. The fully automated process localizes, removes, collects and counts particles on the inner surfaces of FOUPs and FOSBs, including the door. It is the ideal in-line system to considerably improve the quality control of wafer production processes. There is no equivalent.

## Advantages

- Throughput up to 14 carriers per hour depending on recipe types with overhead hoist transportation
- Particle detection from 0,1 to 5 micrometers on all FOUP surfaces
- Option available : 10 nanometers counter (Condensation Particles Counter)
- No cross contamination due to a system of purge of the picking line
- Continuous control of the cleanliness of the ISO class 2 mini environment
- Options available : Load Port Purge
- Fully automated monitoring of carriers (shell and door)
- Fully automatic with a manual or Overhead Hoist Transportation loading
- SEMI & SECS / GEM compliance





**Process description**

The same process is repeated six times to get a measurement of all FOUP surfaces.

**Step 1 :** FOUP sent to the Tool by OHT and automatically loaded onto the Tool

**Step 2:** Particle removal, collection and counting

- Particle are removed from one face by compressed dry air, collected, counted and analyzed
- The cycle is repeated for each FOUP face including door

**Step 3 :** FOUP unloaded and collected by OHT



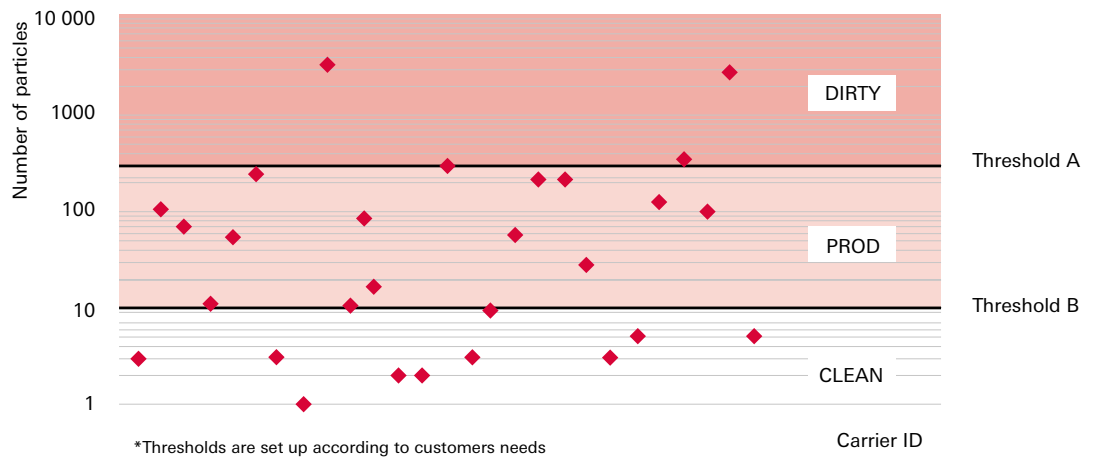
# ADPC 302 – Dry Particle Counter

Particle contamination monitoring  
inside FOUPs and FOSBs in the  
semiconductor industry

## Comparison of liquid vs. dry particle counter

	Analysis	Test duration	Automatic measurement	Particle localization	Carrier door control
State of Art Process – Liquid Particle Counter	Off-line	30 minutes	No	No	No
Advanced Process – ADPC 302	In-line	7 minutes	Yes	Yes	Yes

## Carrier characterization

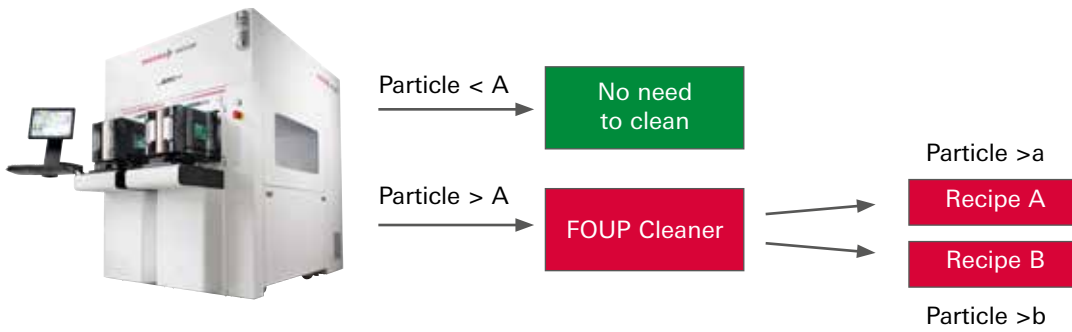


◆ = Particles level of 1 FOUP

**Application examples**

**Pre clean**

- To optimize the cleaning cycle



**Post clean**

- To understand which processes are contaminating FOUPs
- To control the cleanliness of the FOUP after cleaning
- To control FOUP cleaning Tools



# APR 4300 – Pod Regenerator

Yield enhancement and airborne molecular contamination management



Your added value



Queue  
time relaxation

## An innovative solution

Moisture and airborne molecular contamination (AMC) such as evaporated fluorine are released in the FOUPs slot-to-slot space during queue times. These elements can generate crystal growth or other defects on patterned wafers which leads to yield loss and performance degradation. APR 4300 is the unique patented solution to remove AMC from wafers and FOUPs during queue time.

## Advantages

- Four FOUPs / cycle
- Flexible configuration
- SEMI S2 compliance
- Investment savings
- No FOUP modification
- Less N<sub>2</sub> purge utilization

Decontamination efficiency



Yield enhancement



Savings on manufacturing costs

**Process description**

**Step 1:** Conditioning to working pressure

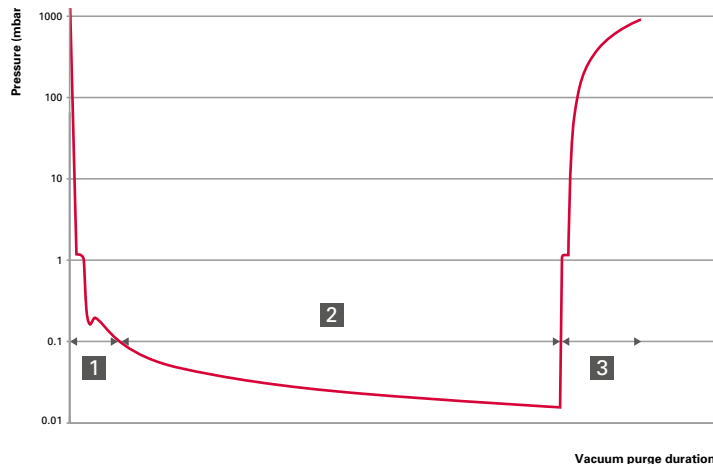
- Pressure management
- Primary pumping
- FOUP laser monitoring (deformation)

**Step 2:** Vacuum purge process

- FOUP desorption
- Wafer desorption

**Step 3:** N<sub>2</sub> purge to atmospheric pressure

- FOUP passivation
- Wafer passivation

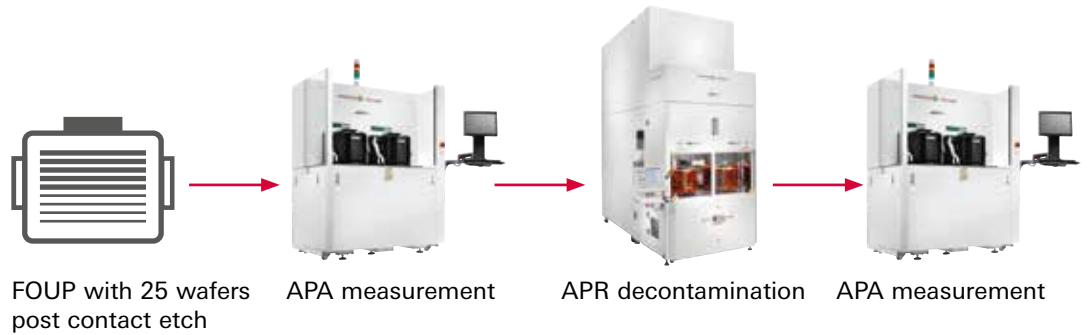


# APR 4300 – Pod Regenerator

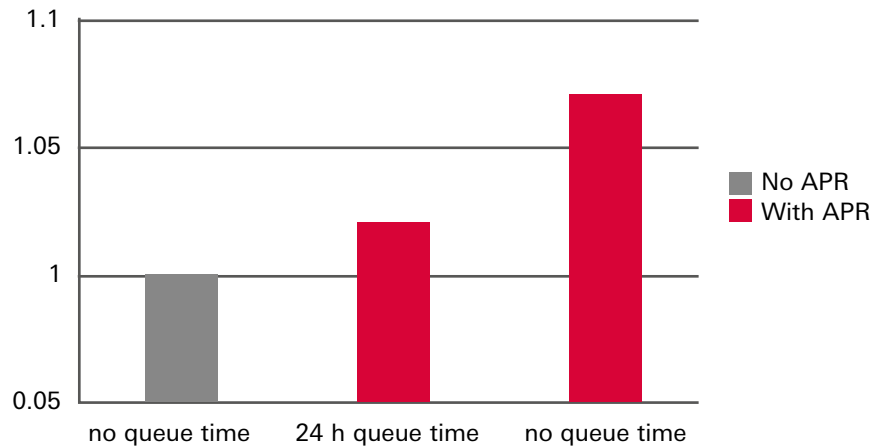
Yield enhancement and airborne molecular contamination management

## Significant performances

High decontamination efficiency for yield enhancement up to 7%



## Efficiency of APR



	Post contact etch	Post APR	Contamination removal
Total acid	14.5 ppbv	1.5 ppbv	90 %
Ammonia	130 ppbv	4 ppbv	98 %

**Application examples**

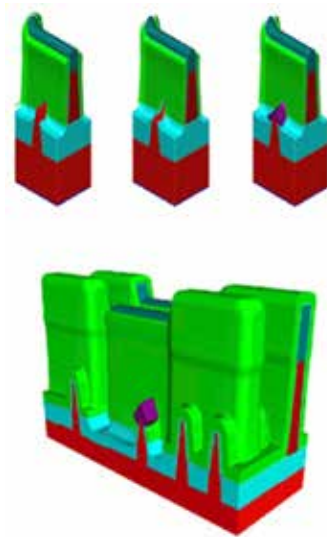
**Pre epitaxy cleaning**

Possible defects



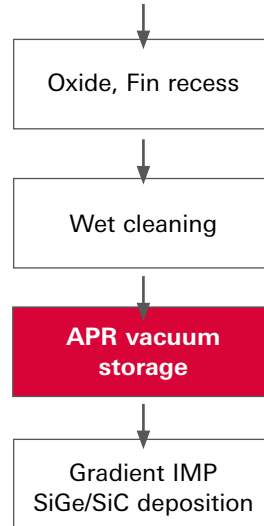
SiO<sub>x</sub> due to O<sub>2</sub> and humidity

Degradation of epitaxy quality (heteroepitaxy)



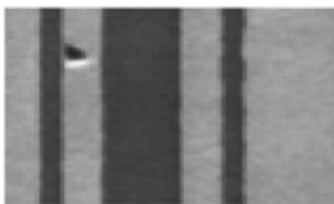
1x nm technologies

**APR deployed steps**

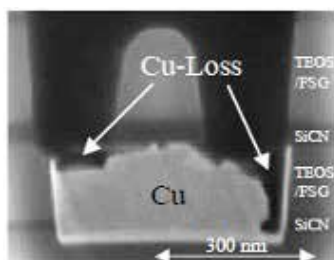


**Copper (Cu) InterConnect**

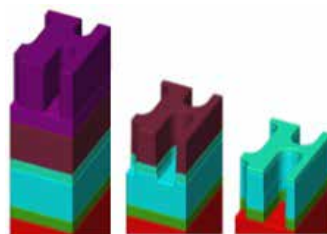
Possible defects



Cu voids

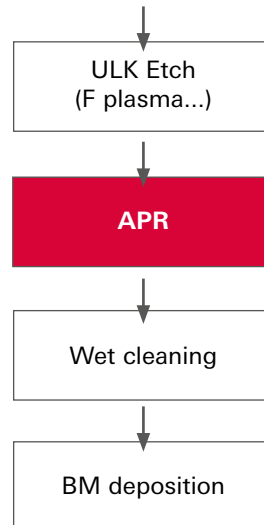


Cu loss



2x nm, 1x nm technologies

**APR deployed steps**



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worldwide!

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All information is subject to change without prior notice. PA 0071 PEN (January 2023/PoD)

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