



# Trace Analysis Services for Controlled Environments

Exyte Technology



# Air Quality Monitoring

## Exyte Group at a Glance

With a history of more than 100 years Exyte Group is a global leader in engineering and project management specialized in the delivery of high-technology facilities. Our expertise in controlled and regulated environments is key throughout the facilities, plants, and factories we create.

We serve high-tech industries, including semiconductor, life sciences, and data center – having an outstanding reputation with the world’s most technically demanding clients.

The Exyte Group manages projects of all dimensions and offers a full range of services from design to managing turnkey solutions. With our offices worldwide we meet the demands of our clients globally. In 2017, the core of Exyte Group generated sales of 2.5 billion euros with 5,000 highly experienced and motivated employees.

### Exyte Technology

Exyte Technology is one of the world’s global leading companies for cleanroom technology systems with extensive experiences in highprecision climate-control systems and contamination control in all industries with ultraclean production requirements.

We offer substantial experience in the semiconductor, photovoltaic, flat-panel, life science, automotive, IT, and food industries. Exyte Technology assists customers in every process phase: from consulting, engineering, manufacturing and commissioning to after sales services.

As a member of the Exyte Group, our worldwide sales and service network is a great advantage to our customers and enables us to support them in every stage of their critical production processes.

## Contamination Detection

Complex and special manufacturing processes in electronic and semiconductor industries require high cleanliness of ambient air. Chemical gas-phase contaminations, so-called airborne molecular contaminants (AMC), can form thin chemical films on critical surfaces. Stringent monitoring of indoor air quality enables to comply with high technology production environments.

Exyte Technology provides expertise in measuring, identifying and controlling air contamination. This enables our customers to improve their manufacturing processes as well as their product yields.

## Cleanroom Air Evaluation and Qualification

The control of air in new cleanrooms and routine monitoring during the production process are essential tasks, in all fields where clean environments for production are required: semiconductor industry, optical and laser technology, pharmaceutical industry, medical technology, life science and food.

**Our portfolio includes:**

- Air sampling indoors, within makeup air units, recirculation systems, in mini environments and tools
- Careful selection of the sampling points for root cause analysis if higher level of contamination is detected
- Choice of appropriate sampling method
- Assessment of purification measures (chemical filters)
- Evaluation according to current international technology and customer specifications

# Control of Media

## Quality Control of Gaseous Media

Pure gases are used in many fabrication processes in the semiconductor, LED, flat panel and optical industry. They are used as purging gases for cleaning and setting up inert atmospheres, dilution and carrier gas, reaction gases and pneumatic drives. For most processes pure and ultrapure qualities are required.

Avoiding disastrous effects on product quality and process flow, high purity gases should be continuously analyzed and monitored.

### Therefore, we offer:

- Analysis of clean dry air (CDA), N<sub>2</sub>, He, Ar, CO<sub>2</sub> and others
- Advanced sampling procedure to handle higher pressure and flow
- Sample collection of acids and bases by impinger method for ions chromatography (IC) and mass spectrometry (ICP-MS) analysis
- Sample collection of organic compounds and refractories by sampling with adsorption materials (e.g. Tenax, CarboTrap) and TD-GC/MS analysis

### Detected Substances:

- Total VOC
- Total SVOC
- Organic amines
- Special individual compounds
- Refractory compounds
- Acids/anions
- Bases/cations
- Metals

Analysis of Organic Air Contamination



Analysis of Acids and Bases in Air



Air Sampling via Impinger



Sampling Points Outgassing Test



Air Quality Monitoring





# Material Outgassing

### Prequalification of Materials

Reducing all kinds of air contamination is a main goal in manufacturing of contamination-sensitive products like wafers, optics, lasers and processes like extreme ultraviolet (EUV) lithography.

Outgassing from materials and devices for cleanroom equipment (e.g. construction materials, floor coatings, sealing compounds, installation, consumables) is the most significant contamination source for volatile organic compounds (VOC). Analysis of outgassing behavior of materials used in clean environments is a first important step to minimize the emission potential of AMC and to improve the indoor air quality.

### Material Outgassing Tests

The concentration of airborne molecular contaminants is a relevant cleanliness factor and has a significant impact on production processes and product quality. Especially the major emitters VOC and ammonia are of substantial interest. We are a member of the Cleanroom Suitable Materials (CSM) network and therefore work according to the guidelines and standards of CSM.

### Our AMC measurement and evaluation procedure encompasses:

- Outgassing test for organic compounds (VOC+SVOC) according to Exyte Technology guidelines and VDI 2083-17 standard
- Evaluation corresponding to Exyte acceptance criteria for cleanrooms and mini environments
- Determination of material-specific standardized ISO-AMC<sub>m</sub> class as well as ISO-AMC<sub>CR</sub> class for actual cleanrooms
- Analysis by thermal desorption (TD)-GC/MS
- Issuing a Exyte certification for tested equipment, materials, components and products

# Material Outgassing

### Product & Process Control for Optical and Laser Device

Besides the importance within semiconductor industry, clean environments are also essential in the manufacturing of optoelectronic products (LEDs) and laser systems as well as in applications like laser metrology. Outgassing of organic compounds, especially condensable compounds were identified as the main source for deterioration of optics.

Organic contamination can lead to hazing on surface of optics, degradation of the coating, reducing the signal transmission or the laser signal itself and can enhance the probability of laser damage.

Sources of organic outgassing can be seals, circuit boards, cable insulation, cleaning agents, coatings, resins and others. Critical compounds are siloxanes, aromatic amines and high boiling aromatic hydrocarbons like phthalates.

### The product and process control includes:

- Component and material testing for production control
- Screening analysis of organic compounds by thermal desorption
  - Analysis of total VOC
  - Evaluation of low, medium and high boiling organic compounds
- Issuing of Exyte Technology certificates



Material Outgassing

Micro Emission Chamber

Material Outgassing Test Vials with Samples

TD GC/MS Analysis

Sampling via Tenax





# Ultrapure Water Measurements

## Trace Analysis

The process and the product quality can be affected by contaminated rinsing water that contains different organic and inorganic contaminants. By integrating all technologies for water purification, the purity of water is upgraded to an ultra-high level by removing particles, organic and inorganic components as well as gases that are dissolved.

The semiconductor industry requires increasingly stringent tolerance limits for contaminants in ultrapure water, especially for critical metals and TOC. This demands a carefully structured, analytical test program for critical parameters like ions, metals, particles, organic compounds and bacteria in order to ensure a high quality of UPW.

## Guaranteed Purity of Water in Production Areas

Ultrapure water is essential to semiconductor fabrication, whereby complex and specific technologies require a great amount of water at every stage of the wafer manufacturing process. Within the immersion lithography ultrahigh purified water is used as a part of the optical system.

### Our services include:

- Test of water quality in a process tool or mini environment for UPW conditioning
- Testing the water quality in the overall system from point of entry (POE) to point of use (POU)
- Controlling water quality at several transfer points
- Pre-qualification of ultrahigh purity (UHP) polymer materials (tubes, hoses, membranes etc.) for UPW distribution systems by static or dynamic leach out tests
- Validation of ion exchange resins and filter systems used for UPW systems

# Ultrapure Water Measurements

## Leaching Test

Polymer materials and components used in UPW distribution systems are potential sources of contamination that can negatively affect the water quality. For that purpose ultrahigh purity (UHP) polymer materials that are used within the production process have to fulfill precise SEMI standard specifications. Therefore, the pre-qualification of these materials is indispensable before they are used within UPW systems.

### Testing of materials

- Tubing
- Piping
- Valves
- Fittings
- Gaskets
- Membranes

### The following material testing procedures are provided by us:

- Static leaching test of tubing, piping, membranes, valves, O-rings according to SEMI F40 in cleanrooms class 5
- Test conditions  $85 \pm 5^\circ\text{C}$ , 7 days (other test conditions can be applied)
- Analysis of ionic, metallic and organic contamination
- Determination of particle contamination in a rinse test according to SEMI F104
- Evaluation of compliance with SEMI F57 contamination specifications
- Dynamic leaching tests, i.e. continuous flow for classification of UPW through a part or assembly, according to SEMI standards and customer specifications

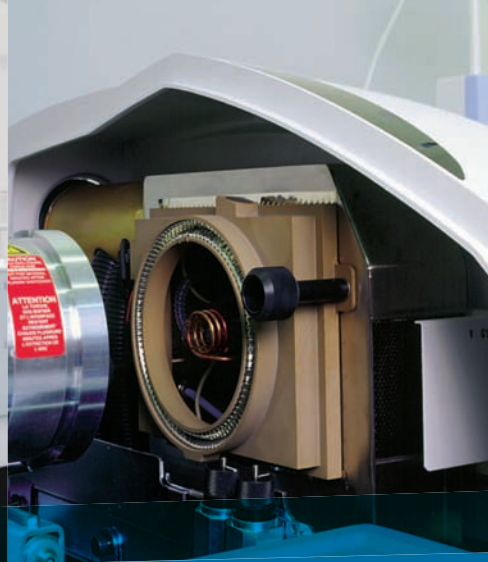
Ultrapure Water Sampling Bottles



Ultrapure Water Measurements



ICP-MS interface



Sample Preparation for Leach Out Test



Leaching Test



# Chemical Filter Testing

### Chemical Filter Technology

Chemical filters are used in a wide variety of applications for the contamination control of ambient and circulating air. Monitoring and filtration are usually done in the ppb range. The AMC Team of Exyte Technology offers comprehensive service for testing new as well as proofing of chemical filter materials that have to meet the highest quality requirements. The development of filter materials is focused on removal of all kinds of acidic, basic and organic substances.

Our AMC Team is equipped with several test rigs and air handling units with precise air conditioning for filter tests:

- Dosage of various test substances for simulating relevant cleanroom contaminations (e.g. SO<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, NO<sub>x</sub>, TMB, ozone and others) can be realized
- Testing of several filter materials: modified charcoal, ion exchange raisins, modified inorganic adsorbent materials and others
- Online measurement devices as well as offline sampling (impinger method and adsorbent tubes) are available

### The filter testing program provides results about:

- Advanced sampling procedure to handle higher pressure and flow
- Determination of removal efficiency
- Filter capacity
- Remaining life time test after a time period of using within its life time cycle
- Filter stability
- Ability for regeneration
- Outgassing behavior of filter materials and components
- Pressure drop measurement



Gas Mixing Panel



Media Test Unit



Filter Test Units



Solvent Vaporizer



Pressure Drop Measurement

# Analysis Methods

### Chemical Analysis for Organic Contamination

Our Trace Analysis Area is equipped with state-of-the-art analytical equipment and calibrated instruments. All analytical tests are conducted using standardized or in-house procedures. We provide gas chromatography with mass spectrometry (GC / MS) equipment for the quantification and identification of organic compounds and an online TOC analyzer for the determination of organic compounds in ultrapure water.

### Thermal Desorption Gas Chromatography coupled with Mass Spectrometry (TD - GC / MS)

Gas chromatography-mass spectrometry coupled with a thermal desorption unit is a universal method for the identification and quantification of a wide range of volatile as well as semi-volatile organic compounds in complex chemical environments. Air samples are collected on thermodesorption tubes packed with one or more solid adsorbents. Within a semi-quantitative screening analysis total organic compound quantities will be reported as well as the most abundant peaks can be identified by means of mass spectra libraries.

Substance	Analytes	Sample type
Total VOC	Volatile organic compounds $\geq C_6$	Ambient and indoor air, CDA, outgassing tests of cleanroom materials, products and components chemical filter  Adsorbents: e.g. Tenax TA, Carbotrap 300
Total SVOC	Semi volatile organic compounds $\geq C_{16}$	
Organic amines	Aliphatic and aromatic amines, amino alcohols, amides	
Special individual compounds	PGMEA, ethyl lactate	
Refractory compounds	Organic compounds with heteroatoms (except N,O): e.g. Si, S, P, F, Cl	
Typical limits of quantilation (LOQ)*		0.01 - 0.1 $\mu\text{g} / \text{m}^3$ in air

\* The LOQ in air can vary depending on the sampling time and rate and will be adjusted corresponding to the project requirements. LOQ corresponds to reference standard n-Hexadecane.

### Total Organic Carbon (TOC)

Our highly-sensitive on-line TOC analyzer provides continuous monitoring of organics in ultrapure water and is able to deliver high-quality results down to a TOC concentration of 0.1 ppb. It enables quick and accurate measurements on-site to ensure the relevant demands for water quality.

The analyzer will be installed directly at the place of measurement and the concentrations can be recorded directly on the device. Individual samples, e.g. aqueous extracts, can be filled in sample vials and analyzed in a special offline mode.

Analysis	Analysis medium	Measuring range
TOC	ultrapure water (UPW)	0.1 - 2,500 ppb

# Analysis Methods

## Chemical Trace-Analysis for Metals and Ions

For the determination of elemental contamination in the ppt range, ICP - MS is the method of choice. Ion chromatography is applied if the concentration of ionic species (anions, cations) in water is in focus.

Substance class	Analytes	Sample type
Trace elements and dopants	Au, Ag, Al, B, Ba, Ca, Co, Cr, Cu, Fe, Ga, Ge, Hf, K, Li, Mo, Mg, Mn, Na, Ni, P, Pt, Sr, Ti, Zn,	<ul style="list-style-type: none"><li>• Ultrapure water (UPW)</li><li>• UPW impinger for air samples</li><li>• Diluted aqueous samples</li></ul>
Typical limits of quantitation (LOQ)*		1 - 10 ng / L in UPW
		0.01 - 0.05 µg / m³ in air

\* The LOQ in air can vary depending on the sampling time and rate and will be adjusted corresponding to the project requirements. Lower LOQ < 1 ppt in UPW are available on request.

## Ion Chromatography (IC)

Ion chromatography is the ideal method for analyzing anions, cations and other polar substances in aqueous media. A specific instrument design allows the simultaneous analysis of

## Inductively Coupled Plasma Mass Spectrometry (ICP - MS)

Inductively coupled plasma mass spectrometry (ICP - MS) is an elemental analysis technique for quantitative trace element analysis. It can detect almost all elements of the periodic table. Our ICP - MS system has an excellent sensitivity and can operate down to sub-ppt limits, lower than most other analytical methods.

anions and cations from the same sample. Using a specific pre-concentration technique enables ultra-trace analysis down to the lower ppt-range.

Substance	Analytes	Sample type
Acids / anions	F <sup>-</sup> , Cl <sup>-</sup> , Br <sup>-</sup> , NO <sub>2</sub> <sup>-</sup> , NO <sub>3</sub> <sup>-</sup> , ClO <sub>3</sub> <sup>-</sup> , SO <sub>4</sub> <sup>2-</sup> , PO <sub>4</sub> <sup>3-</sup> , formiate, acetate, oxalate	<ul style="list-style-type: none"><li>• Ultrapure water (UPW)</li><li>• UPW impinger for air samples</li><li>• Diluted aqueous samples</li></ul>
Bases / cations	NH <sub>4</sub> <sup>+</sup> , NH <sub>3</sub> , Li <sup>+</sup> , Na <sup>+</sup> , K <sup>+</sup> , Mg <sup>2+</sup> , Ca <sup>2+</sup>	<ul style="list-style-type: none"><li>• Ultrapure water (UPW)</li><li>• UPW impinger for air samples</li><li>• Diluted aqueous samples</li></ul>
Typical limits of quantitation (LOQ)*		1 - 10 ng / L in UPW
		0.01 - 0.05 µg / m³ in air

\* LOQ can vary depending on sampling time and rate, impinger volume and enrichment factor. They will be adjusted corresponding to the project requirements.

# Analysis Methods

## Online AMC Measurements

On-line analyzers are generally used for analyzing gaseous media. They enable fast and continuous analysis with real-time response of airborne molecular contamination and provide

results with high accuracy and precision. Using our online analyzers simplifies the test setup and sampling process and make enables an enormous time saving.

Substances of interest	Analysis technique	Measuring range
SO <sub>2</sub> /H <sub>2</sub> S/DMS	UV Fluorescence	0.5 - 10.000ppb
NO / NO <sub>2</sub> / NO <sub>x</sub>	Chemiluminescence detector	
NH <sub>3</sub>		
Ozone	UV Absorption	
Organic compounds	FID	0 - 10,000 mg C / m³

## Filter Test Installations

Our AMC Team is equipped with several filter test rigs. Using high precision dosing options for gases and solvents like NOx, SO<sub>2</sub>, H<sub>2</sub>S, DMS, HCl, NH<sub>3</sub>, ozone, siloxanes, toluene, xylene and IPA nearly any kind of contamination relevant to cleanrooms

can be simulated. Our online measurement equipment measures gas concentrations, temperature, humidity, air flow rate as well as pressure drop.

Test installation	Analyses	Specifics
Filter test installation	Testing of AMC filters on <ul style="list-style-type: none"><li>• filter efficiency</li><li>• capacity</li><li>• life-time</li></ul>	<ul style="list-style-type: none"><li>• High precision dosage of several gaseous media and solvents</li><li>• Online gas analyzers</li><li>• Offline sampling by impinger and adsorption materials for analysis by ion chromatography and TD - GC / MS</li></ul>
Outgassing test installation	AMC outgassing tests for filter materials	<ul style="list-style-type: none"><li>• Outgassing tests of tool and ceiling filters as well as construction materials</li><li>• AMC sampling by impinger and adsorption materials and analysis by ion chromatography and TD - GC / MS</li></ul>

## Particle Measurement

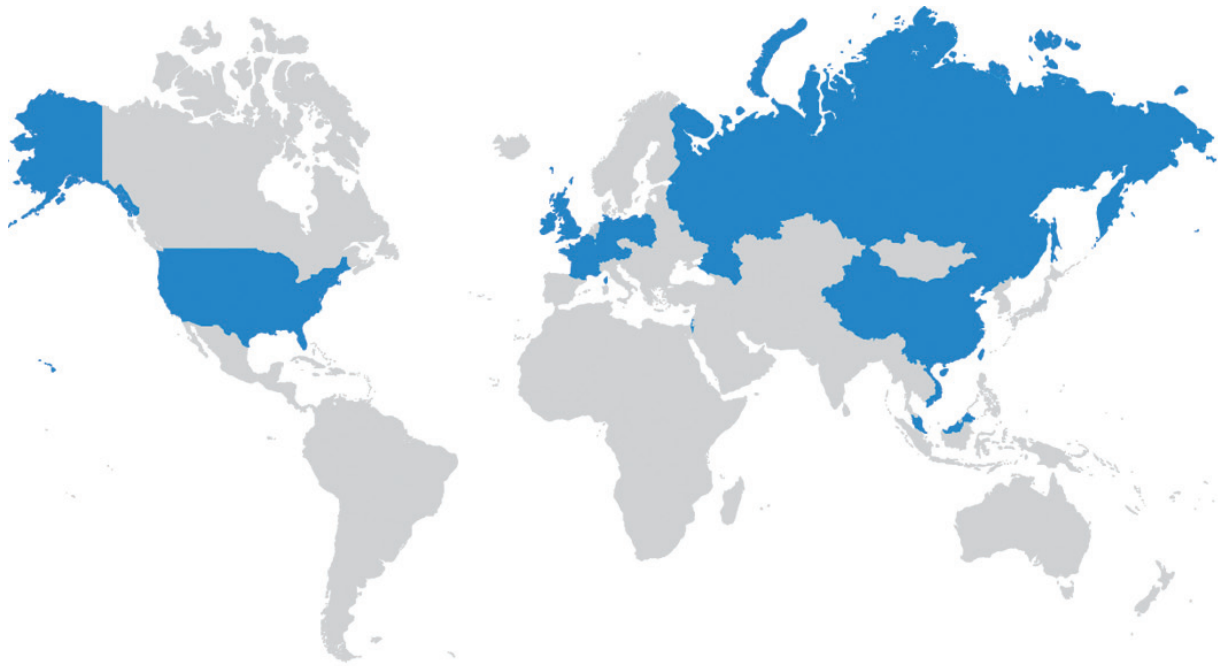
Available laser-based particle counters are used for measuring the particle concentration in air and water. Our laser article counters specifically designed for particle measure-

ments in air or water can count and size particles as low as 0.1 µm in air and 50 nm in water respectively.

Analysis	Analysis medium	Measuring range
Particles	UPW	≥ 0.05 µm
Particles	air	≥ 0.1 µm



# Local Support Wherever You Need Us



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