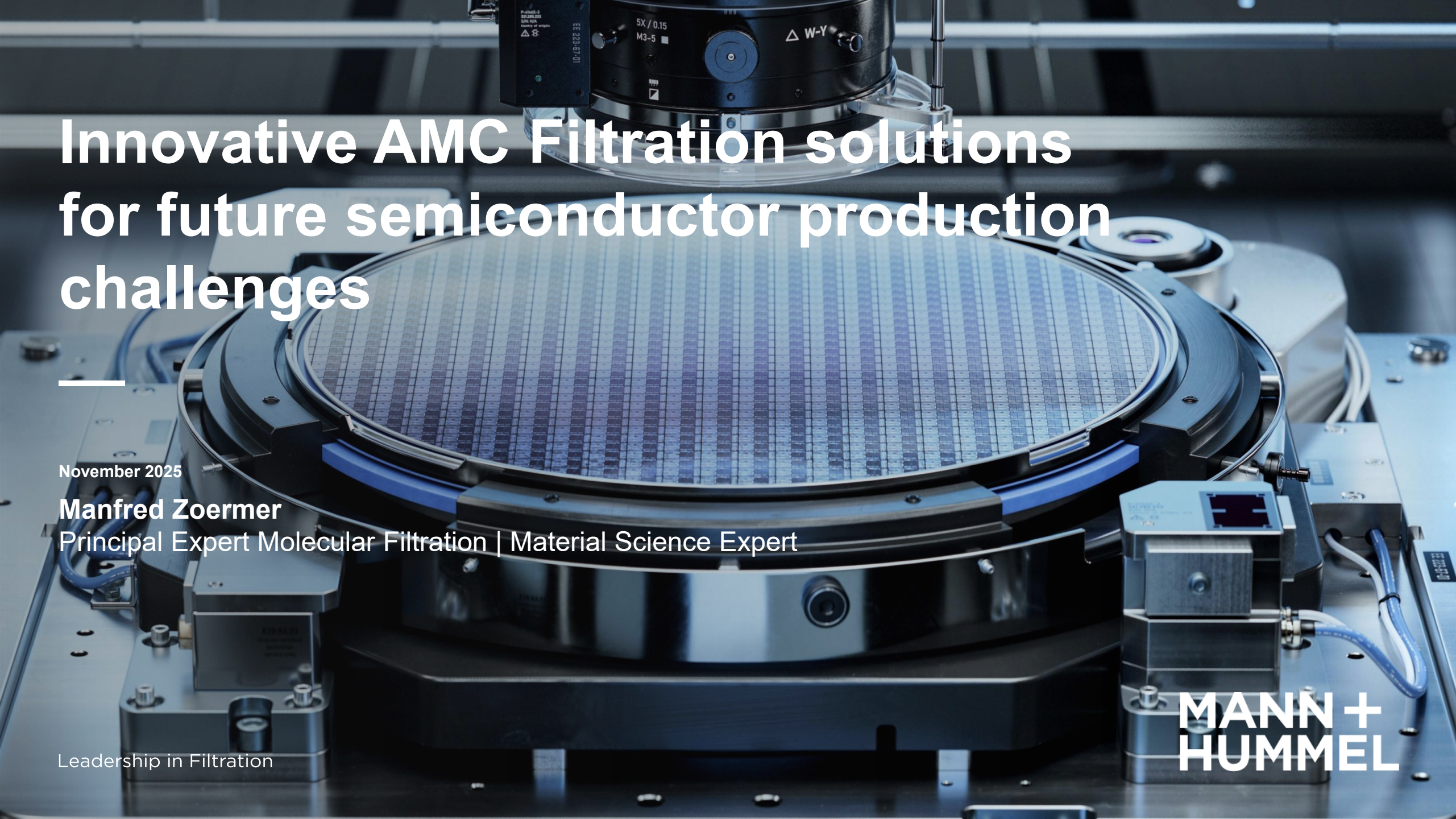




Innovative AMC Filtration solutions for future semiconductor production challenges

November 2025

Manfred Zoermer

Principal Expert Molecular Filtration | Material Science Expert

Leadership in Filtration

**MANN +
HUMMEL**

THE COMPANY IN FIGURES

Over 80 years of filtration experience.



FOUNDING YEAR

1941

in Germany



R&D EMPLOYEES

1,116

worldwide



EMPLOYEES

21,224

worldwide

PATENT
APPLICATIONS**70+**

per year



LOCATIONS

80+

on 6 continents

PATENTS AND
APPLICATIONS**4,300**

overall



TURNOVER

4.5

EUR billion

UNIVERSITY
PARTNERSHIPS**60+**

We separate the **useful** from the harmful.

Cleaner air:

We ensure that the air you breathe is safe

Cleaner industry:

With smart industrial filtration we make industries more efficient



Cleaner mobility:

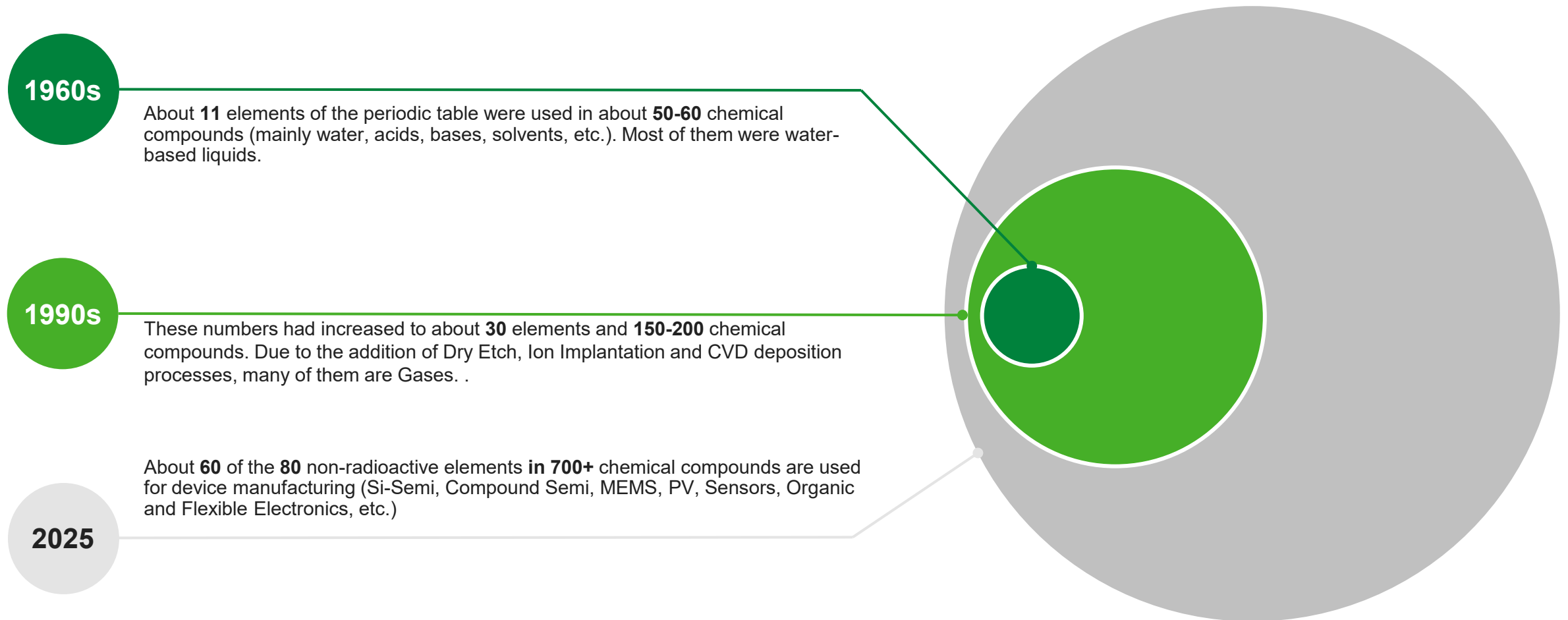
We make sustainable, emission-neutral mobility possible

Cleaner water:

We provide cleaner water worldwide

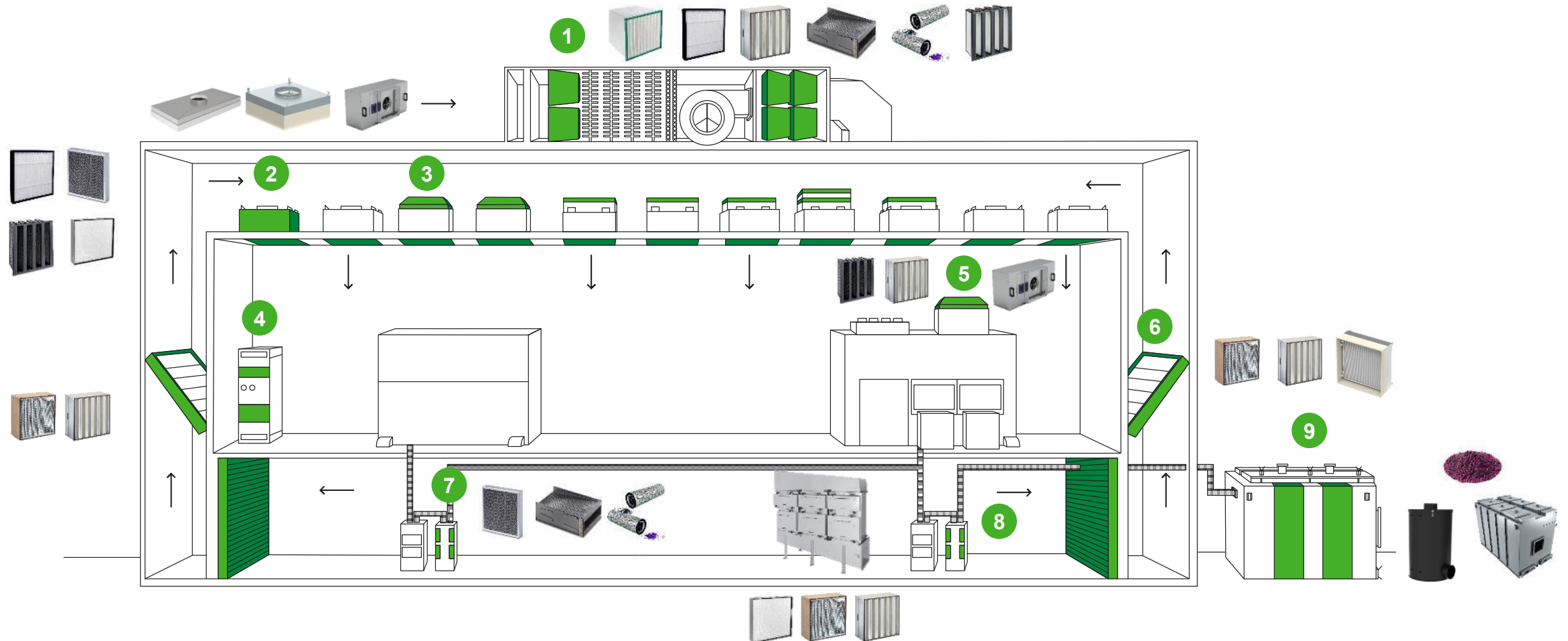
COMPARISON

The Development of Semiconductor Processing Technology



FILTER SYSTEMS FOR A CLEAN ENVIRONMENT

Schematic illustration of cleanroom filter systems applications



FILTER SYSTEMS FOR A CLEAN ENVIRONMENT

Filter System Setup in a Cleanroom

Cleanrooms need FFU's – FFU's need Filter Elements – Prefilters are changed frequent, even the Molecular Filters

1. Cleanroom with FFU ceiling



2. Cleanroom ceiling from below



3. Cleanroom ceiling from above



4. Filter fan unit

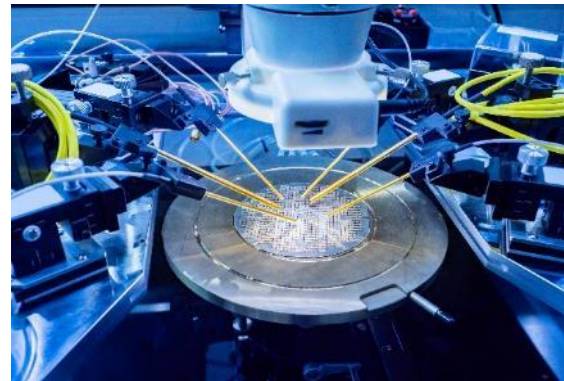


5. Filters used (selection)



Sources of AMC in Sensitive Production Processes

- Humans
- Outdoor air
- Production processes
- Volatile emissions of process equipment and chemical supply circuits
- Cross contamination between production areas
- Storage areas of chemicals
- Gas release of buildings and building materials
- Accidentally spillage
- And many more



Consequences of AMC Contamination

Disrupted production process



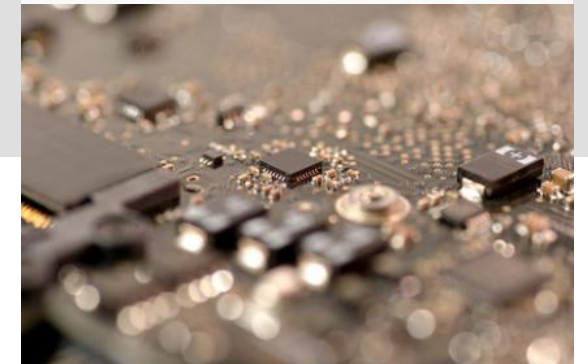
Health of employees



Damage of particle filters



Corrosion



Impact on all aspects of the value chain!

Types of Airborne Molecular Contamination (AMC)

The definitions are as follows:

- **Acid (MA):** corrosive material whose chemical reaction is that of an electron acceptor
- **Base (MB):** corrosive material whose chemical reaction is that of an electron donor
- **Condensable (MC):** chemical substance capable of condensation on a clean surface (excluding water)
- **Dopant (MD):** chemical element that modifies the electrical properties of semiconductive material
- **Molecular Metals (MM):** a trace metal that may exist either in elemental form such as Al, W, Mn, Pb, etc., or as a compound, such as AlCl_3 , WF_6 , etc.

Another group of chemicals that has become more important for contamination control is **refractory compounds**.

This category refers to:

- **volatile organic compounds (VOCs)**
- **semi-volatile organic compounds (SVOCs)**

They can contain, for example, sulfur (S), phosphorus (P), or silicon (Si), and they form surface molecular contamination on reticles, optics, inspection equipment, etc.

Types of AMC

Acids	Bases	Condensables**	Dopants	Refractories
Hydrogen fluoride (HF) Hydrogen chloride (HCl) Sulfur dioxide (SO ₂) Hydrogen sulfide (H ₂ S) Acetic acid (CH ₃ COOH)	Ammonia (NH ₃) N-Methyl-2-pyrrolidone (NMP) Triethylamine (TEA) Trimethylamine (TMA) Ethanolamine (C ₂ H ₇ NO)	Propylene glycol methyl ether acetate (PGMEA) NMP Trimethyl benzene Triethyl phosphate (TEP) Butylated hydroxytoluene (BHT)	Boron trifluoride (BF ₃) Boric acid (H ₃ BO ₃) Tris (2-chloroethyl) phosphate (TCEP) TEP	Trimethyl silanol (TMS) Hexamethyl disiloxane (HMDSO) Octamethyl cyclotetrasiloxane (D4) TEP Tetrachloro ethylene (PCE)

**condensables as defined by SEMI (boiling point >150°C)

* Source: SEMI (Semiconductor Equipment Manufacturers International)

Effects of AMC*

Toxicity:

- causes damage to living tissue, impairment of the central nervous system, or (in extreme cases) death

Corrosiveness:

- likely to cause deterioration or damage to the interiors of buildings and / or its contents

Irritation:

- causes discomfort and potentially permanent damage to exposed people

Odors:

- primarily affects the sense of smell

Contaminant Types (example semicon):

	Toxic	Corrosive	Irritants	Odorous
Representative Compounds	Ammonia Arsine Boron trifluoride Chlorine Hydrochloric acid Hydrofluoric acid Methyl alcohol Nitric acid Methylene chloride Phosphine Phosphorus pentafluoride Silicon tetrafluoride 1,1,1-trichloroethane	Acetic acid Ammonia Chlorine Fluorine Hydrochloric acid Hydrofluoric acid Nitric acid Nitrogen dioxide Ozone Sulfur dioxide Sulfuric acid	Acetic acid Acetone Ammonia Chlorine Formaldehyde Isopropanol Methyl alcohol NMP Ozone PGME PGMEA Toluene Xylene	Acetic acid Ammonia Butyl acetate Chlorine Formaldehyde Hydrofluoric acid Hydrogen sulfide Isopropanol NMP PGME PGMEA Phosphine Xylene

AMC-control systems protect **products** and **processes** but also **people**!

* Source: SEMI (Semiconductor Equipment Manufacturers International)

Systems for AMC-Control

- HVAC
- Additional air systems
- Recirculation air systems
- Exhaust air systems
- Closed systems (mini- / microenvironments)

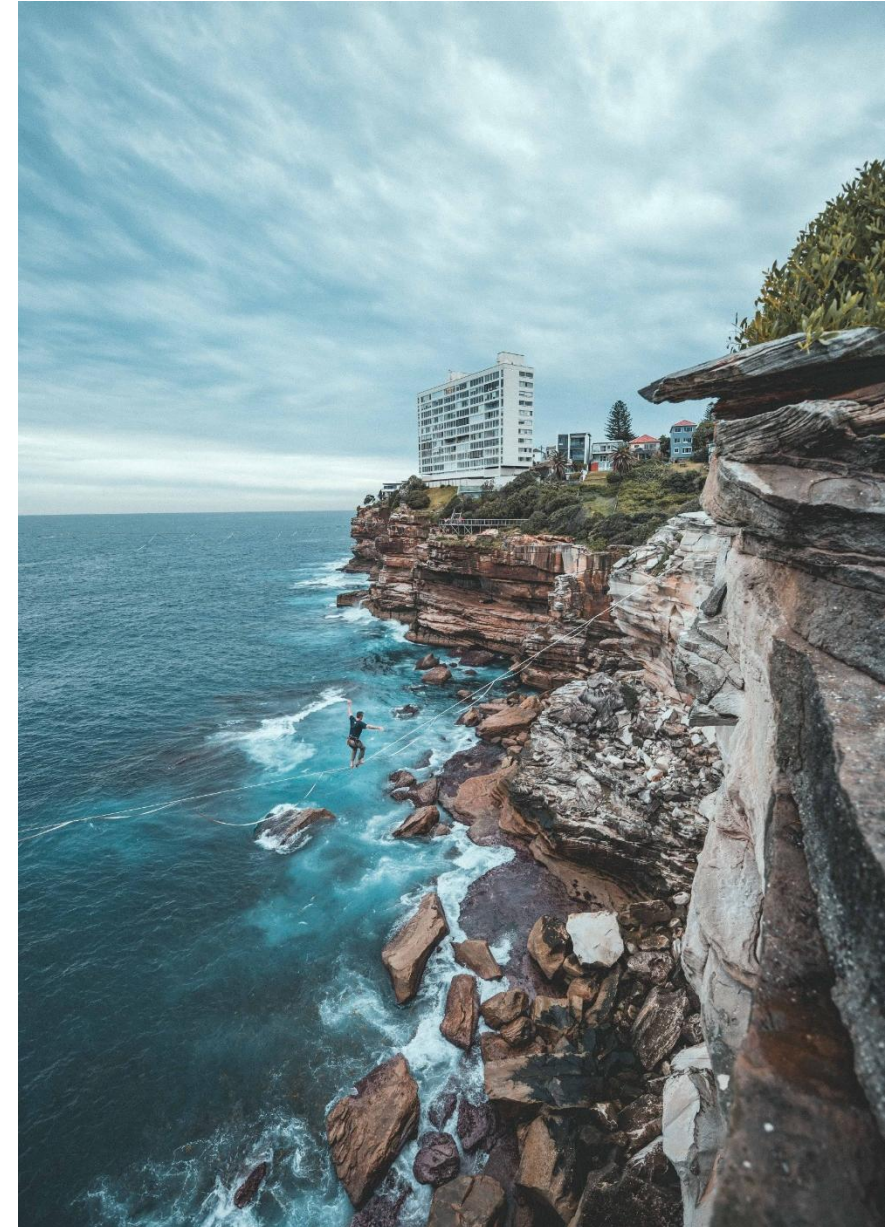
Example measurement in different airstreams:

Contaminant measured	Outside airstream	Recirculation airstream	Cleanroom air	Mini-environments
Acetic acid	3,0 mg/m³	242 µg/m³	88-44,2 µg/m³	
Acetone	31-166 mg/m³	3,9 mg/m³	38,95 µg/m³	
Ammonia				1,46-3,48 mg/m³
Benzene	11,6-60,4 µg/m³	3,13 µg/m³	5,61 µg/m³	
n-Butyl acetate	0,32 mg/m³		2,63 µg/m³	
Chlorine		1,2-10,9 µg/m³	5,6-12,3 µg/m³	
Decane		1,87 µg/m³	2,26-6,11 µg/m³	
Dichlorobenzene			0,6 µg/m³	
Ethoxyethylacetate			1,67 µg/m³	
Ethylbenzene	5,8-8,8 µg/m³	0,97 µg/m³	10,15 µg/m³	

Contaminant measured	Outside airstream	Recirculation airstream	Cleanroom air	Mini-environments
Ethyltoluene		0,99 µg/m³	1,60-7,67 µg/m³	
Formaldehyde	12,28-49,13 µg/m³		38-65 µg/m³	
Freon 113	4,4 mg/m³			
Hydrogen sulfide				0,31-0,70 mg/m³
Isopropanol	1,5 mg/m³			
Isopropylbenzene			0,79 µg/m³	
Methyl ethyl ketone	1,2 mg/m³			
Methyl mercaptan				0,04-0,10 mg/m³
Methylamine				0,15-0,38 mg/m³
Nitrogen dioxide	0,291-1,457 mg/m³			
NMP	0,65 mg/m³	12-25 µg/m³	30-40 µg/m³	0,82-2,5 µg/m³
Ozone	0,10-0,40 mg/m³	20-80 µg/m³	10-20 µg/m³	
Styrene		1,19 µg/m³	2,36 µg/m³	
Sulfur dioxide	0,08-0,37 mg/m³	15-200 µg/m³	10-15 µg/m³	
Tetrachloroethylene		0,99 µg/m³	3,97 µg/m³	
Toluene	33,3-157,6 µg/m³	0,93 mg/m³		
Trichloroethane		3,09 µg/m³	40,98 µg/m³	
Trichloroethylene			0,61 µg/m³	
Trimethylbenzene		0,79-1,77 µg/m³	1,80-9,91 µg/m³	
Xylene	0,34 mg/m³	7,3-153,9 µg/m³	9,28-36,39 µg/m³	
TVOC	195 µg/m³	84-110 µg/m³	129,67 µg/m³	17,85 mg/m³

Future Challenges by AMC Pollution

- Metalorganic compounds are applied in Thin Films processes, i.e. (MO)CVD, ALD, MOVPE
- Metalorganics inherit nasty chemical properties, featuring properties that have at minimum one of the following attributes:
 - toxic, very toxic, flammable, highly flammable, pyrophoric, corrosive, oxidizing, hypergolic, mutagenic, teratogenic, carcinogenic...
- There is a growing drive to utilize CVD and ALD processes due to a need to incorporate deposition processes that are not to be realized by physical processes like PVD or similar
- Decentralized process gas and chemicals distribution systems, i.e. process gas and chemical supply systems, that are incorporated into or installed by design into process tools (ex. MOVPE)
- Maintenance and cleaning of exponentially growing process tools (now up to 450mm / 18 in. wafer size)



Chemical challenges caused by release in cleanrooms

Additional cleaning processes:

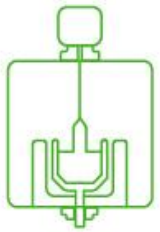
- Anodizing baths - dipping process
- Flat Panel Display Tool cleaning
- Abrasive and CO₂ blasting
- Plasma spray coating
- Chemical bath cleaning
- Ultrasound cleaning
- Ceramic coating
- Final parts check and release

Parts Cleaning Range:

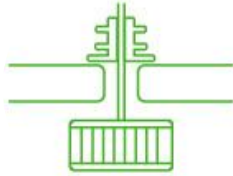
- Semiconductor Equipment parts
- Semiconductor Inspection equipment parts
- Vacuum equipment parts
- Thin film coating equipment parts
- Parts of linear motors
- Heat screens
- Flat Panel Display Equipment parts
- Adhesion equipment parts
- Parts of positioning equipment
- Sensor parts
- Analytical equipment parts
- Ultrasonic generator parts
- Electrical screens and isolators



Typical semiconductor processes and process tools, including components



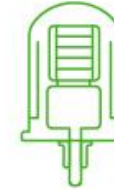
Single crystal pulling device



Vacuum furnace /
Pressure furnace



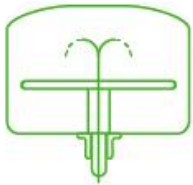
Sputtering equipment



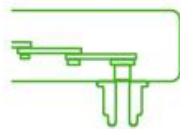
CVD equipment



Etching equipment



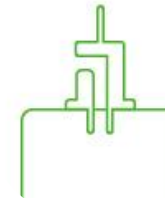
Epitaxial growth equipment



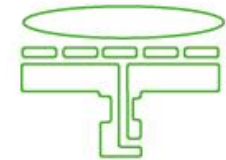
Vacuum robot



Ion implanter



Gas introduction machine

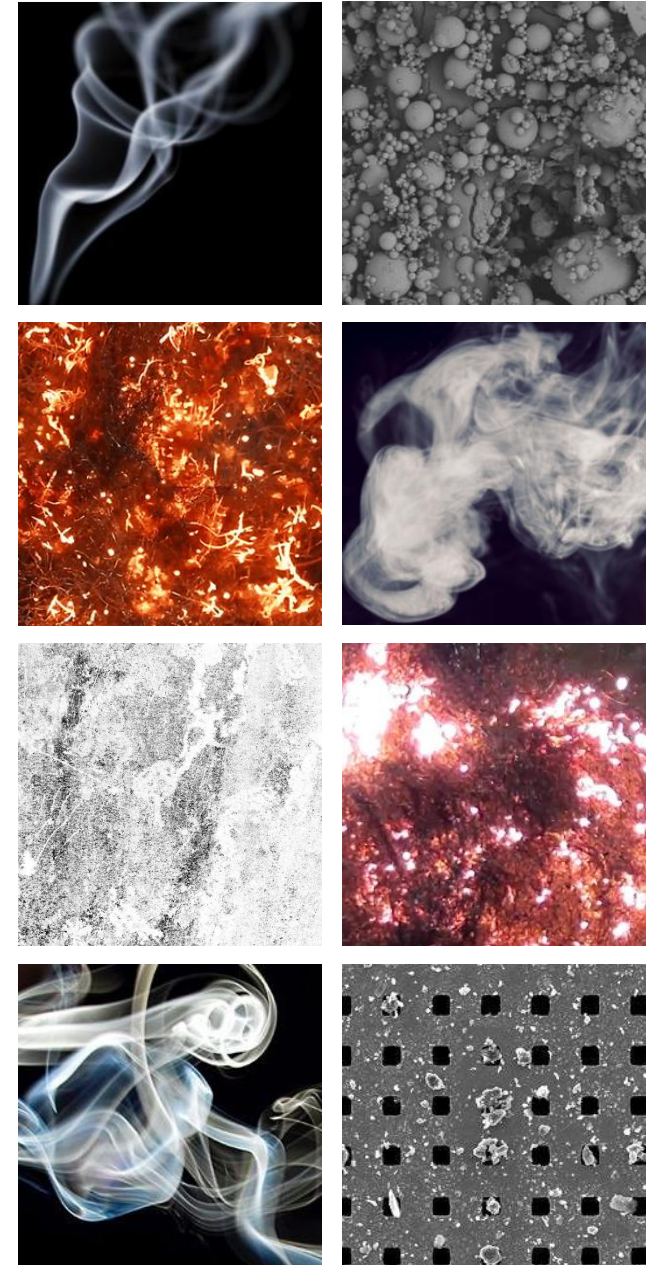


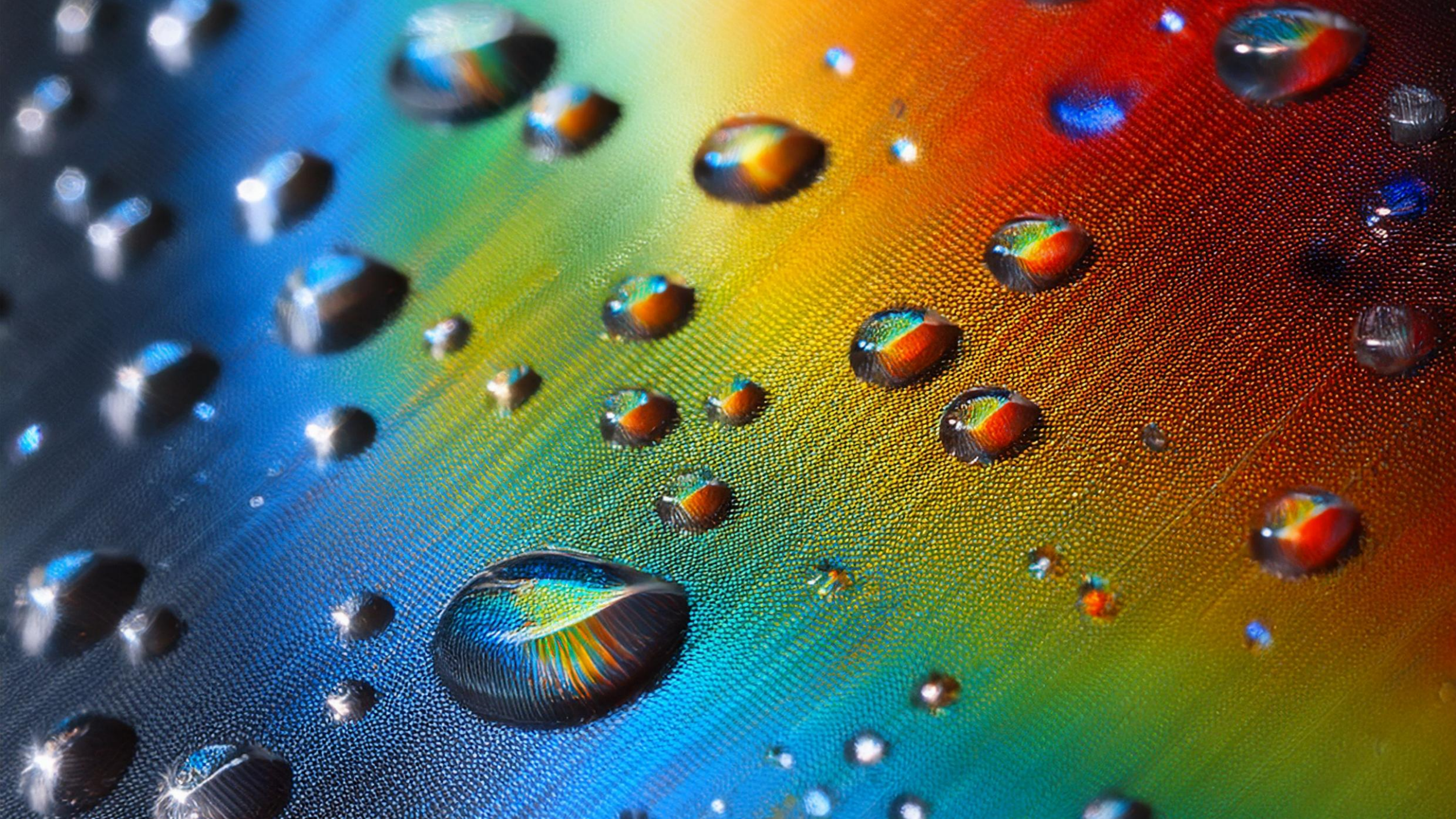
Vacuum chuck

Visualization of potential Consequences

How toxic vapours and fumes are created by pyrophoric (spontaneously combustible) process materials and chamber deposits

- Ignition temperatures of pyrophorics is located around or, at maximum, a little above room temperature. They nearly immediately start glowing upon contact with air and ignite shortly after, often generating fumes or smoke. Pyrophorics and pyrophoric deposits typically feature a very large specific surface, similar to a sponge. Atmospheric oxygen is hereby chemisorbed fast, reacts immediately and therefore the oxidation energy leads to ignition.
- Self igniting matter sometimes deatures a silent oxidation, where in its course the spongelike matter cannot move the heat of reaction to the environment as the sponge has bad heat conduction and therefore keeps the heat of reaction accumulated inside, speeding up the reaction.
- Typically, self igniting or pyrophoric solid materials are usually thinly distributed across larger surfaces, often ceramics or metals like aluminium or stainless steel. Pictures of deposit lined process chamber walls, isolators, pump lines and vacuum parts are numerous.
- Service and equipment engineers sometimes report low volume crackling noise and haze or smoke generation when exposing parts with process deposits to ambient air. Engineers normally wear berathing and eye protection in order to protect themselves from involuntary inhalation. The recirculated cleanroom air however, is considered secondary.





Our AMC filter portfolio for semiconductors



Products



Carboactiv Panel filters

For clean room ceilings, Fan Filter Units, mini-environments or process equipment



Carboactiv Panel HC filters

For FFUs, AHU, minienvironments – best ratio of efficiency, size and dp. Regenerative and high chemical resistance.



Carboactiv Cube filters

For clean room ceilings, Fan Filter Units, mini-environments or process equipment



Carboactiv Panel HC ZeroOhm filters

Molecular filters for explosive atmospheres



Carboactiv Fill

Control of odors, toxic and corrosive chemicals in supply and exhaust air

Services



Filter analyses

Remaining capacity measurement and determination of service life



Calculation of filter service life

Based on existing contamination and operating conditions



Corrosion coupons

Copper and silver coupons for corrosion monitoring (including laboratory analysis)

Danke

谢谢

Merci

ありがとう

Thank you

Grazie

감사합니다

Gracias

धन्यवाद

Obrigado

Tack

Dziękuję

Děkuji

ਤੁਹਾਡਾ ਧੰਨਵਾਦ

Terima kasih



Meet us for a slice
of cake at booth
B1221-2!



Get in contact with us!



MANN+ HUMMEL

✉ MANFRED.ZOERMER@MANN-HUMMEL.COM

☎ +49 162 410 2881

www.mann-hummel.com

