

Marco Kircher

What measures is the semiconductor industry taking to replace PFAS in production processes?

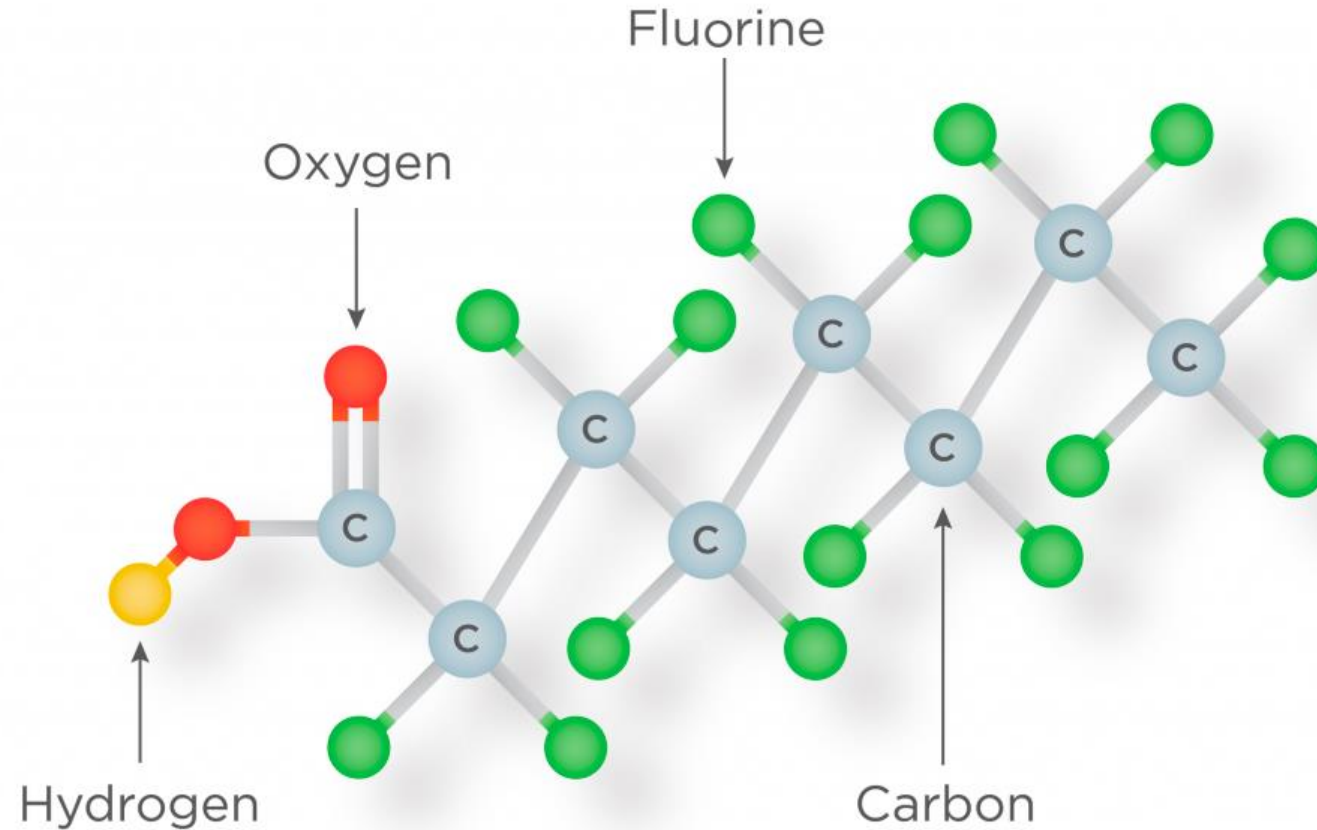
Marco Kircher

are research institutes (RTO)
~~What measures is the semiconductor industry~~
taking to replace PFAS in production
processes?

Marco Kircher

are RTO doing to help the industry
What ~~measures is the semiconductor industry~~
replace PFAS in production processes?

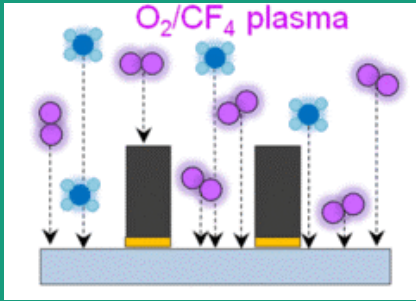
**** - Chemists' wonder weapon, ecologists' nightmare



its

Per- and polyfluorinated alkyl substances (PFAS)

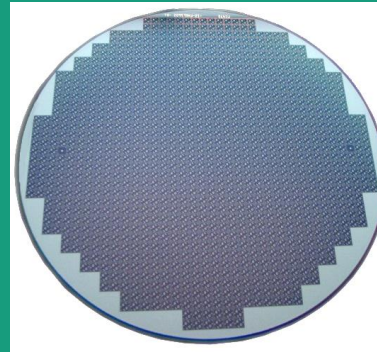
Main areas of application in semiconductor manufacturing



Etching gases



Solvents and photoresists



Coatings



Sealing Materials

Agenda

Next 15min in short

1. Who is Fraunhofer

2. Bundle the Power in semiconductor industry

- FMD Forschungsfabrik Mikroelektronik
- Existing Green ICT @ FMD Project, new Projects

3. Concrete Example how we can replace PFAS in MEMS

Chapter 01



Who is Fraunhofer

The Fraunhofer-Gesellschaft

At a Glance

Applied research focusing on key future-relevant technologies and the commercialization of findings in business and industry. A trailblazer and trendsetter in innovative developments.



> **30,000** employees

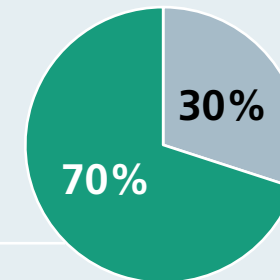


76 institutes and research units

€ **3.4 billion** total funding
€ **3.0 billion** contract research



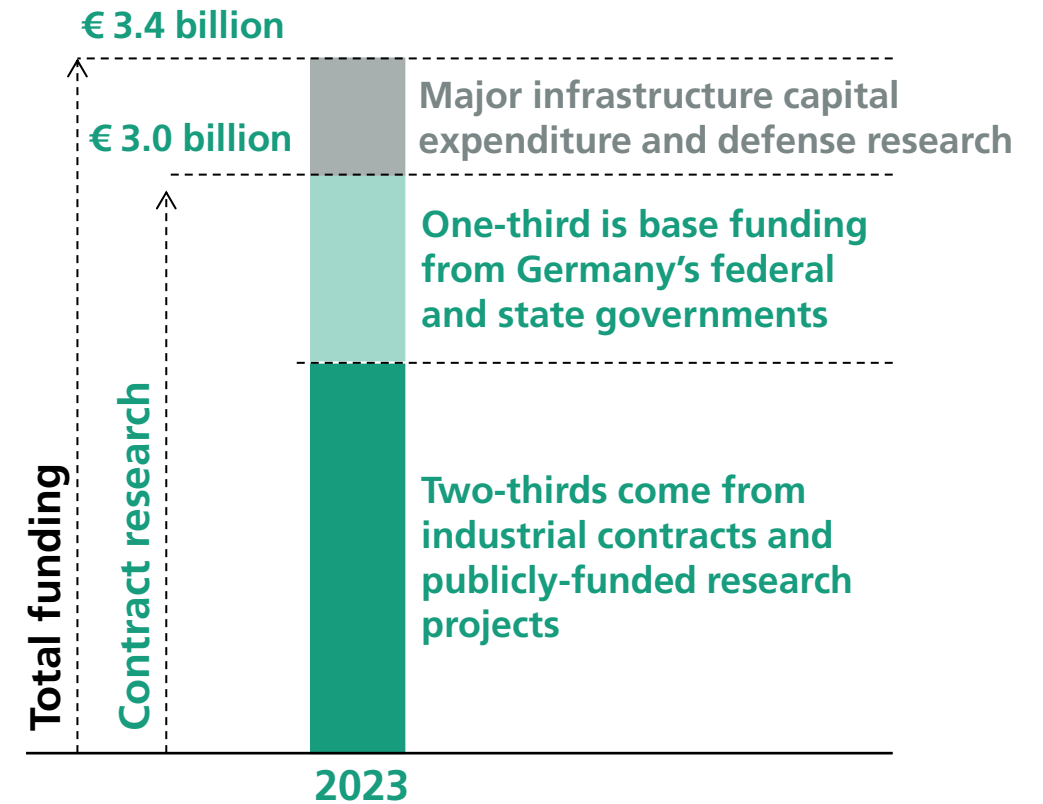
Industrial contracts and publicly-funded research projects



Base funding from Germany's federal and state governments

as of 2022

At a Glance



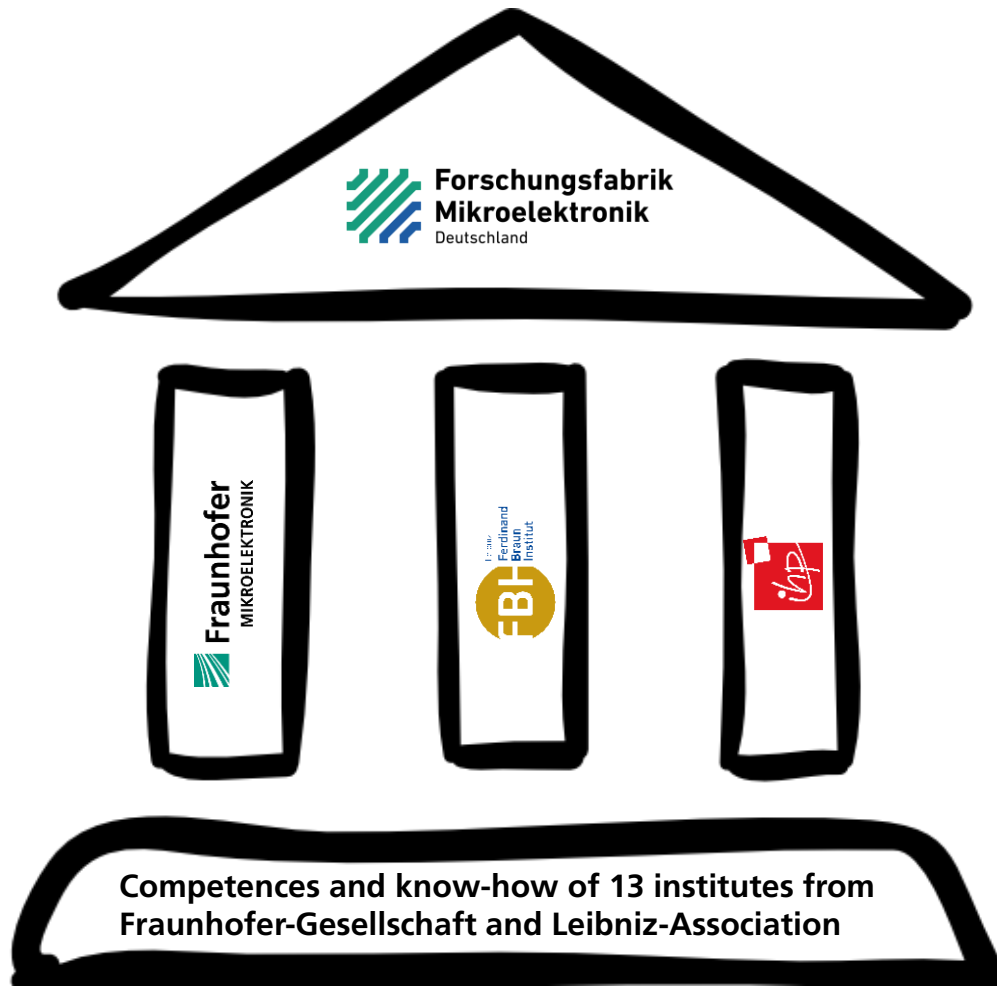
Chapter 02

Bundle the Power



Research Fab Microelectronics Germany (FMD)

One of the largest cross-site R&D cooperations for micro and nanoelectronics in Europe



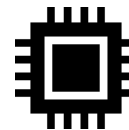
Bringing together research in microelectronics that is spread across many institutes in Germany



Bridging the gap between basic research and customer-specific product development



Providing the broadest range of materials and techniques for innovative solutions



Offering a unique range of expertise and infrastructure



Enabling digital change and future key technologies



Supporting innovators and start-ups

Forschungsfabrik Mikroelektronik Facts and Figures

One of the largest cross-site R&D cooperations for micro and nanoelectronics in Europe



11 institutes from
Fraunhofer
2 institutes from **Leibniz**



Approx. **4,500** employees
with **2,635** scientists



560 m EUR Budget



200 m EUR projects/industry
235 m EUR projects/public
funding
125 m EUR basic funding



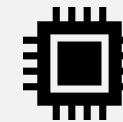
19.500 m² cleanroom
space with **ISO9001**
Certification;
1 MES over 10 institutes



2.200 tools/equipment
in **13 cleanrooms**



2.2 bn EUR assets /
investment

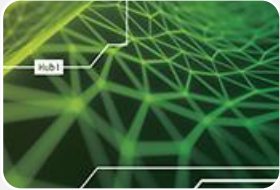


Design (down to 10/12 nm)
Wafer Processing:
GaAs/InP (4"), SiC (6")
Si, SiGe, GaN (8"), Si (12")
Advanced Packaging up to
12"; 600 mm panel
System Integration
Test & Characterization

Competence Center Green ICT @ FMD

3 Technology Hubs – Joint project goals

Hub 1: Sensor-Edge-Cloud



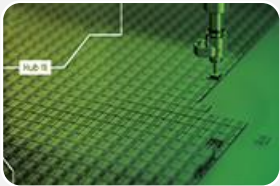
- Embedded green AI
- Self-sufficient IoT-sensor nodes
- Multi-sensor platform
- Green edge computing and edge cloud systems

Hub 2: Energy-saving Communication Networks



- 5G testbed
- X-haul wireless network
- X-haul optical network

Hub 3: Resource-optimized Microelectronics Production



- Processing
- Cleanroom infrastructure
- Energy optimization
- Back-end technologies
- Material reduction and replacement

Project goals

- Pooling **FMD's expertise in the field of ICT** within the Competence Center Green ICT @ FMD
- Establishing a **central contact point** for industrial user groups, to provide answers to their questions
 - Resource-saving microelectronics/MEMS fabrication processes
 - Energy-optimized sensor edge cloud systems and communication networks
 - Life cycle and environmental assessment of existing products and processes
 - Recent and upcoming regulations and the establishment of standards for ICT products and processes
- **Training and encouraging** students, young professionals and employees on issues of relevance to Green ICT
- **Developing a community** of relevant stakeholders in the field of green ICT

Competence Center Green ICT @ FMD

3 Technology Hubs – 2 Possibilities for cooperation

Hub 1: Sensor-Edge-Cloud



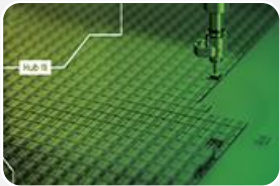
- Embedded green AI
- Self-sufficient IoT-sensor nodes
- Multi-sensor platform
- Green edge computing and edge cloud systems

Hub 2: Energy-saving Communication Networks



- 5G testbed
- X-haul wireless network
- X-haul optical network

Hub 3: Resource-optimized Microelectronics Production



- Processing
- Cleanroom infrastructure
- Energy optimization
- Back-end technologies
- Material reduction and replacement

Industrial user groups

- Identify the most important technological topics together with our experts
- Participate in the latest findings, data and process optimizations
- Network with other stakeholders in your line of business
- Benefit from our expertise in energy and resource optimization of ICT products and processes

Validation projects

- Benefit from our test environments and cleanroom infrastructure
- Adapt modern “green” knowledge to your ICT product or process
 - Learn about the carbon footprint of your ICT product or manufacturing process
 - Reduce costs with 100% coverage of the utilized FMD services

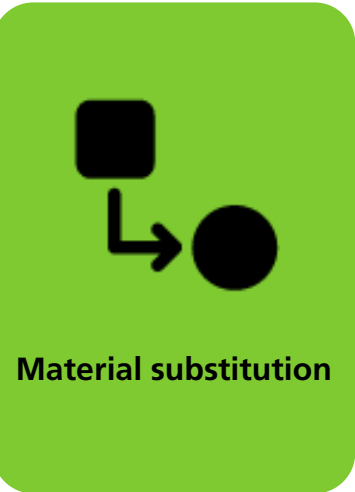
Service Portfolio Hub 3: Microelectronics Production

Ecological design of products and processes – what we can offer

Range of topics

Technological offers

Life cycle assessment offers Environmental potential analysis



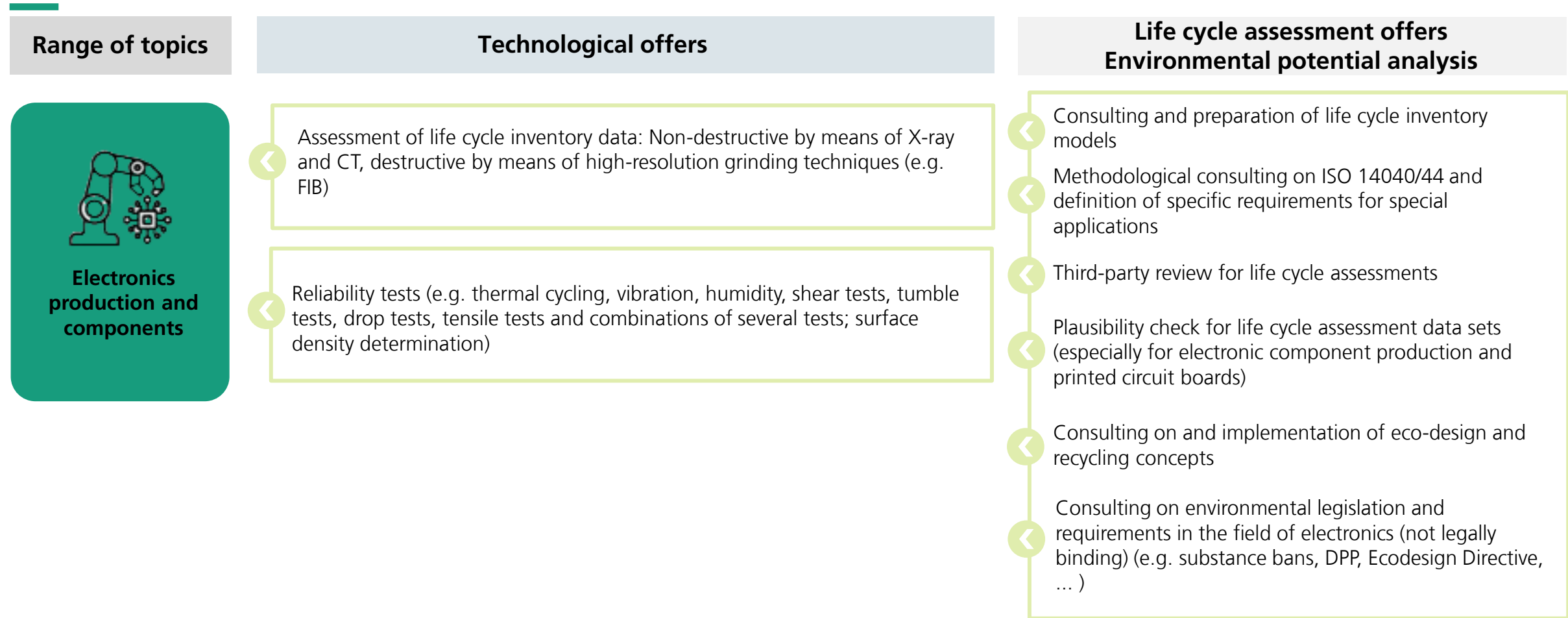
- ◀ EKC265 Substitution for cleaning Si wafers after the Bosch Si etching process
- ◀ Introduction of more environmentally friendly alternatives than EKC265 for cleaning
- ◀ Process optimization with slurries from less critical sources or materials, advice on recycling tools, characterization on test structures
- ◀ Consulting on FAN gas installation, development and optimization of the plasma cleaning concept
- ◀ Process parameters for the production of InGaAs/InAlAs/InP heterostructures on silicon substrates
- ◀ Alternative materials to NMP: testing possibilities through extensive knowledge using different characterisations

- ◀ Use of solvents or solvent mixtures that are not carcinogenic and not very harmful to aquatic organisms
- ◀ EKC265 alternatives: Fluorides, amines, hydroxylamine and pyrocatechol-free, low process temperature, without rinsing with isopropanol
- ◀ Replacement of Ce- by SiO₂-containing slurries; reduction of water consumption in the post-process, recycling and re-use of slurries, determination of consumption and carbon equivalents
- ◀ Replacement of the cleaning gases C₂F₆ and NF₃ with FAN
- ◀ Replacement of He as precursor gas by Ar
- ◀ Arsenic reduction of 99.99 % in electronic high-frequency circuits
- ◀ Process evaluation without NMP

Evaluation of material and energy consumption for entire technology processes in terms of consumption vs. expenditure

Service Portfolio Fraunhofer IZM

Your technological interface with us and our offers for ecological improvements



European PFAS related R&D funding opportunities

Chips Joint Undertaking program



■ Focus Topic

Sustainable and Greener Manufacturing (HORIZON-Chips-2024-2-RIA Topic 2)

1. Increase the use of environmentally friendly materials, chemicals and solvents. Minimization of waste and emissions during production and processing.
2. Prevention of a future scarcity of some critical materials for SC processing through a more efficient and cost-effective products and waste recycling in process.

Research topics

Material research for replacement/alternatives for PFAS in the SC manufacturing process at different TRL levels.

Innovative equipment or processes, as well as innovations in the operation and maintenance of the production lines

Development of abatement systems and capture technologies.

More precise detection of persistent and mobile substances or dangerous materials in waste water.

Chapter 03

Concrete Example how we can replace PFAS in MEMS

Fraunhofer PFAS related R&D

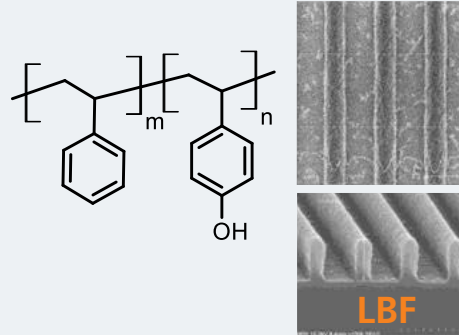
Research topic examples

Material research for
replacement/alternatives for PFAS in the
SC manufacturing process

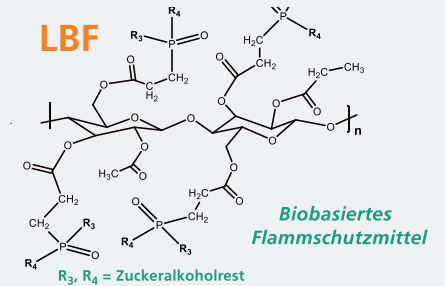
Innovative equipment or processes, as well
as innovations in the operation and
maintenance of the production lines

Development of abatement systems and
capture technologies.

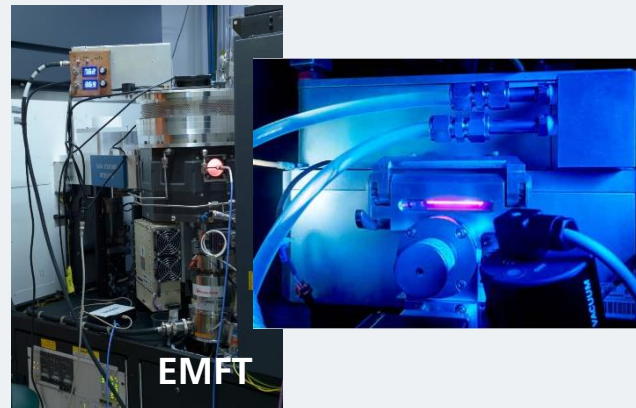
Well defined Polymers
as binders for photoresists



Novel bio-based
flame retardants



DRIE etching with non-PFAS
etching gases and abatement

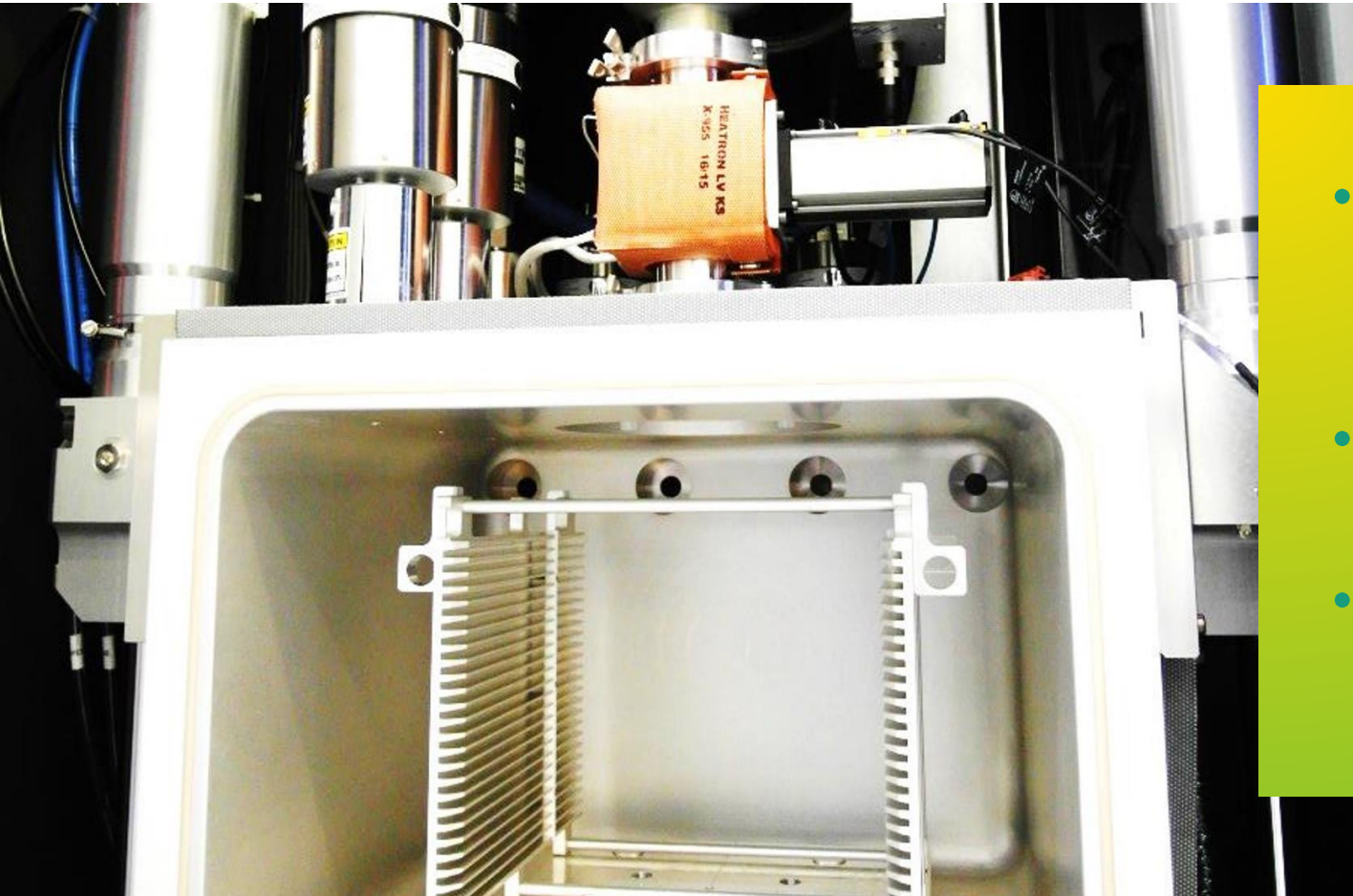


PFAS free anti-stiction coatings



Example 1 - PFAS substitution

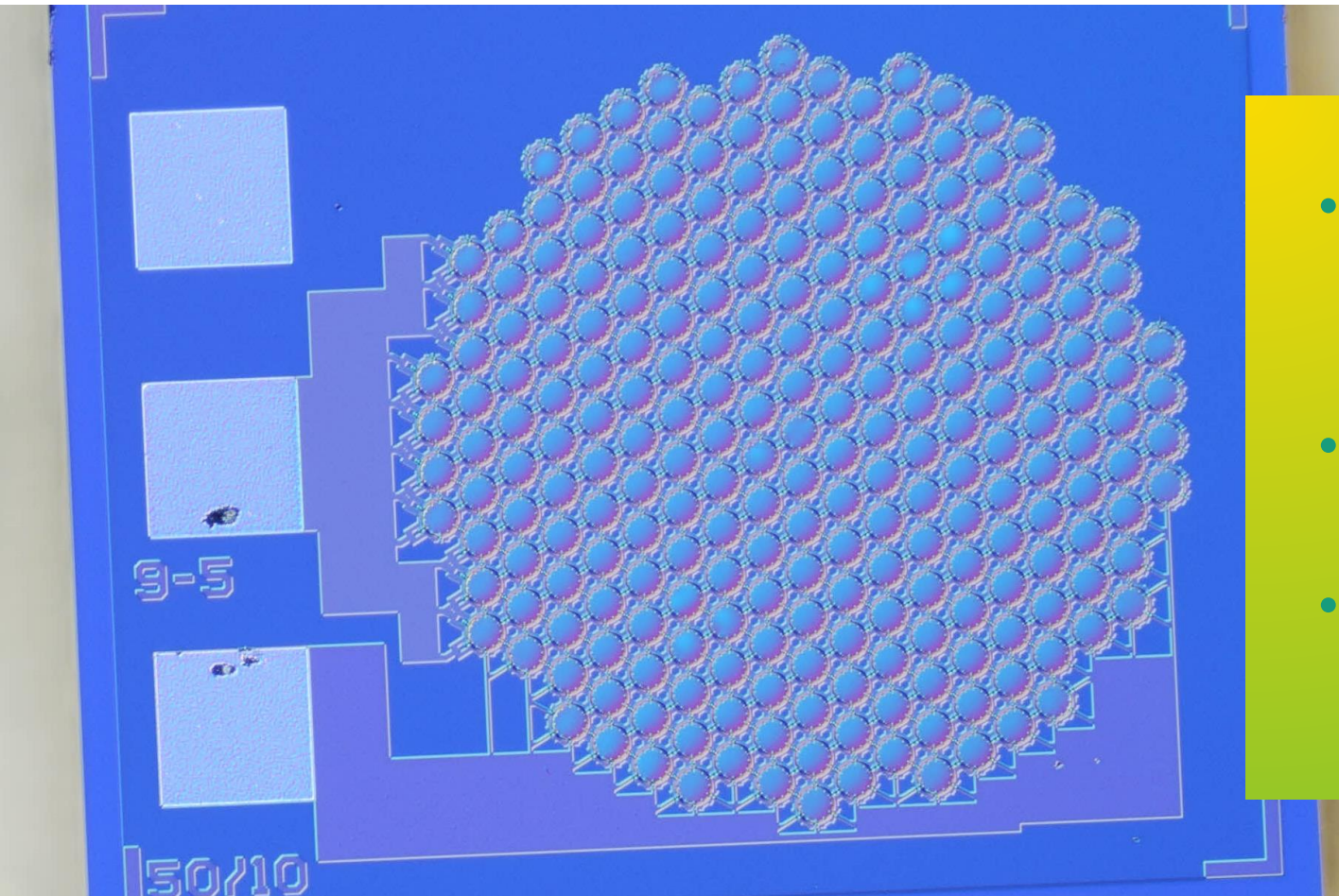
Use - in SAM ALD - SPTS MVD300



- FOTS is a popular non-stick coating and hydrophobic coating for MEMS device surfaces
- e.g. testing the use of OTS, DMMA, Parylene as a replacement for FOTS
- Alternative materials can be proposed by the industry

Example 1 - PFAS substitution – CMUT

Use - in SAM ALD - SPTS MVD300



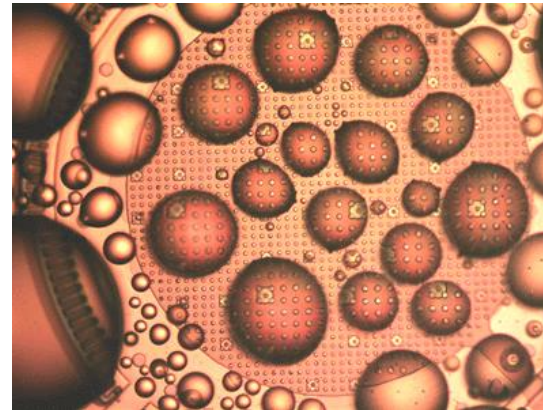
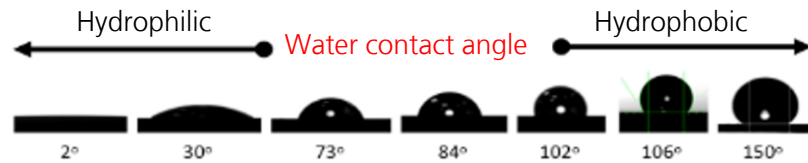
- FDTD is a popular non-stick coating and hydrophobic coating for MEMS device surfaces
- e.g. testing the use of OTS, DMMA, Parylene as a replacement for FDTD
- Alternative materials can be proposed by the industry

Example 1 - PFAS substitution

Analyse of results

Analysis:

- Determination of hydrophobicity (contact angle determination)



- Fully automated measurement/function test on wafer prober systems - fully electrical and also mechanical
- Parameter test, mixed signal through to circuit tests



Your Contact at the FMD Business Office



Dr. Manuel Thesen

Project Manager

+49 171 8491 370

manuel.thesen@mikroelektronik.fraunhofer.de



Dr. Hans Walter

Standardization and Education

+49 173 5840 124

hans.walter@mikroelektronik.fraunhofer.de



Lotta Adu

Environmental Assessment

+49 151 7050 7842

lotta.adu@mikroelektronik.fraunhofer.de



Dr. Daniela Hübler

Green ICT Space

+49 151 7261 9479

daniela.huebler@mikroelektronik.fraunhofer.de



Tuğana Ceren Aslan

Environmental Assessment

+49 151 2136 0503

tugana.aslan@mikroelektronik.fraunhofer.de



Nadiia Telenchuk

Eventmanagement

+49 151 5142 6908

nadiia.telenchuk@mikroelektronik.fraunhofer.de

Contact

Marco Kircher
Business Area CS/ASS/SMA
Tel. +49 12 3456-361
Fax +49 12 3456-255
Marco.Kircher@ipms.fraunhofer.de



Competence Center Green ICT @ FMD

Your Contact for the Green ICT Hubs

Hub 1: Sensor-Edge-Cloud Systems

Josef Bernhard, Hub Management
josef.bernhard@iis.fraunhofer.de

Sylvie Couronné, Deputy Hub Management
sylvie.couronne@iis.fraunhofer.de

Hub 2: Communication Networks

Prof. Dr. Wolfgang Heinrich, Hub Management
wolfgang.heinrich@fbh-berlin.de

Dr. Andreas Wentzel, Deputy Hub Management
andreas.wentzel@fbh-berlin.de

Hub 3: Microelectronics Production

Jörg Amelung, Hub Management
joerg.amelung@ipms.fraunhofer.de

Marco Kircher, Deputy Hub Management
marco.kircher@ipms.fraunhofer.de

Life Cycle Assessment

Dr. phil. Lutz Stobbe
lutz.stobbe@izm.fraunhofer.de

Dr. Nils F. Nissen
nils.nissen@izm.fraunhofer.de

Dr. Marina Proske
marina.proske@izm.fraunhofer.de

Clean Rooms of Fraunhofer IPMS

200 mm MEMS & 300 mm Micro- and Nanoelectronics



200 mm MOEMS/MEMS

- 1500 m², class 10 (ISO 4)
- 200 mm (8") CMOS compatible wafer line
- 3 shift operations for R&D and pilot fabrication
- Technological parameter supervising system
- MES-based planning and documentation
- ISO 9001:2015 certification



[Visit
virtual
tour](#)



300 mm Micro- and Nanoelectronics

- 2700 m², class 1000 (ISO 6) & 400 m² laboratory space
- 300 mm industrial standard equipment
- 80 systems for wafer processing, metrology & analytics
- Certified wafer exchange with industrial fab partners, e.g., in 28 nm / 22 FDX
- Sub-nm characterization and verification



[Watch
video
tour](#)