

Determination of Organic Contaminants on Silicon Wafer Surfaces

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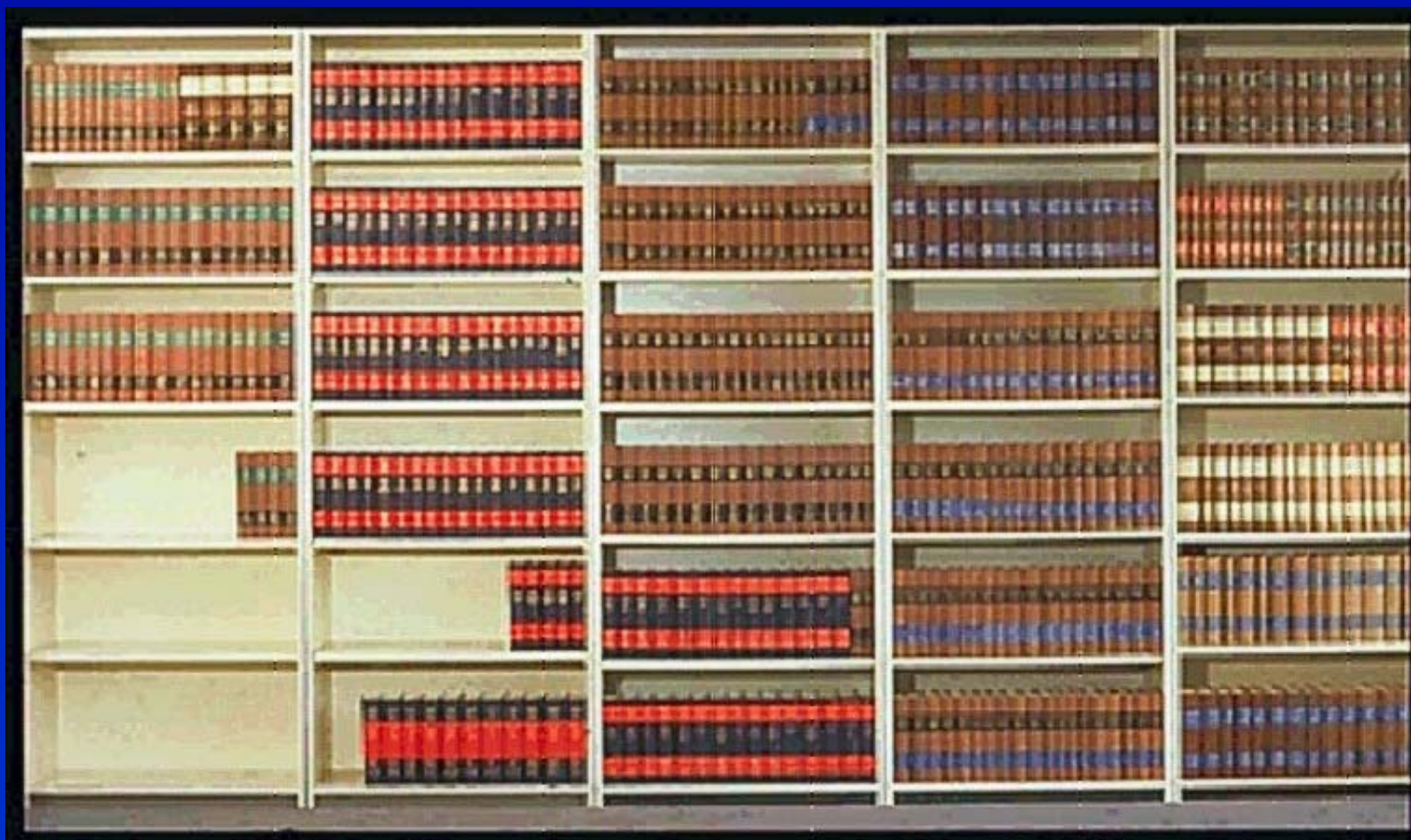
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Impact of Organic Contaminants

- Time Dependent Haze - TDH
- Inadvertent surface etching
- Enhanced metal adsorption
- Disturbance of surface sensitive processes
e.g. photolithography, silicon on glass, plasma TEOS
- Organics undergo degradation, graphitization,
carbonization and formation of SiC during thermal
treatment

Organics

**Approx. 7.5 Mio Organic Compounds according to
Beilstein Handbook of Organic Chemistry**



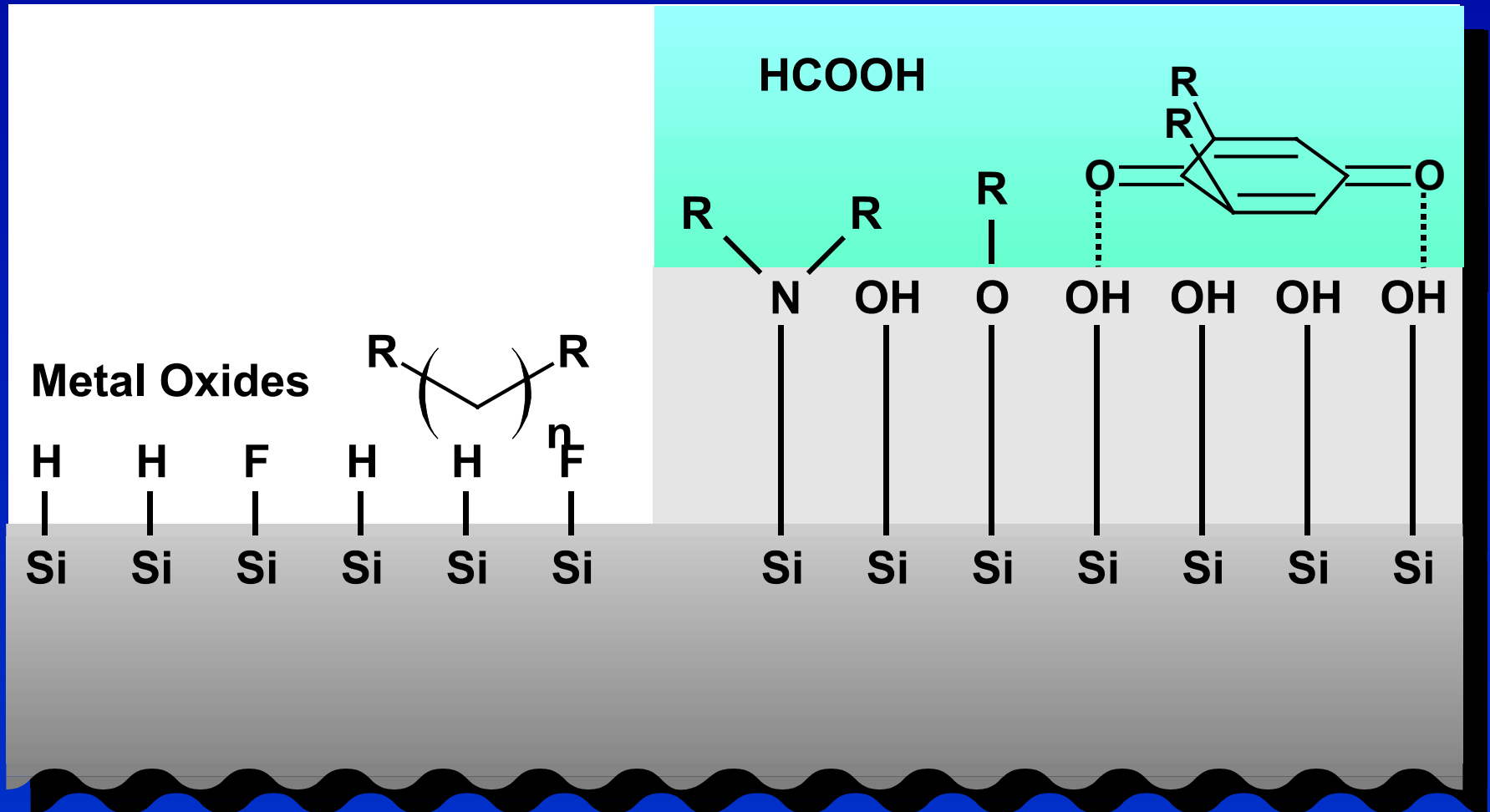
Techniques used at Wacker Siltronic for Monitoring Organic Contaminants

- **IC** **Ion Chromatography**
- **CE** **Capillary Electrophoresis**
- **TD-GC/MS** **Thermodesorption Gas Chromatography / Mass Spectrometry**
- **GC-TOFMS** **Gas Chromatography / Time-of-Flight Mass Spectrometry**
- **TOFSIMS** **Time-of-Flight Secondary Ion Mass Spectrometry**
- **SR-TXRF** **Synchrotron Total Reflection X-ray Fluorescence Spectrometry**

Interaction of Organic with Wafer Surface

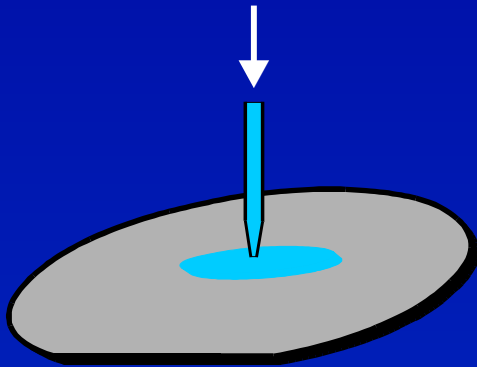
hydrophobic

hydrophilic

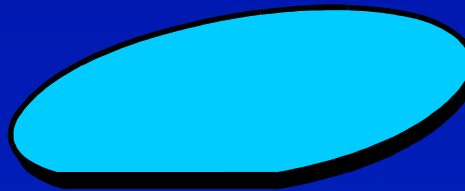


Wafer Surface Water Extraction Method WSWEM

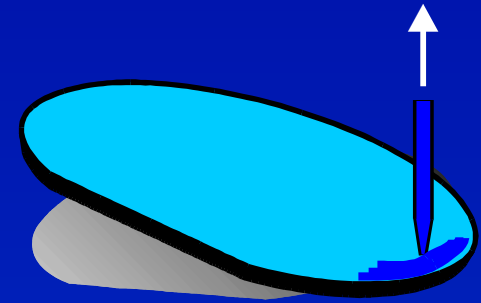
wetting



extraction

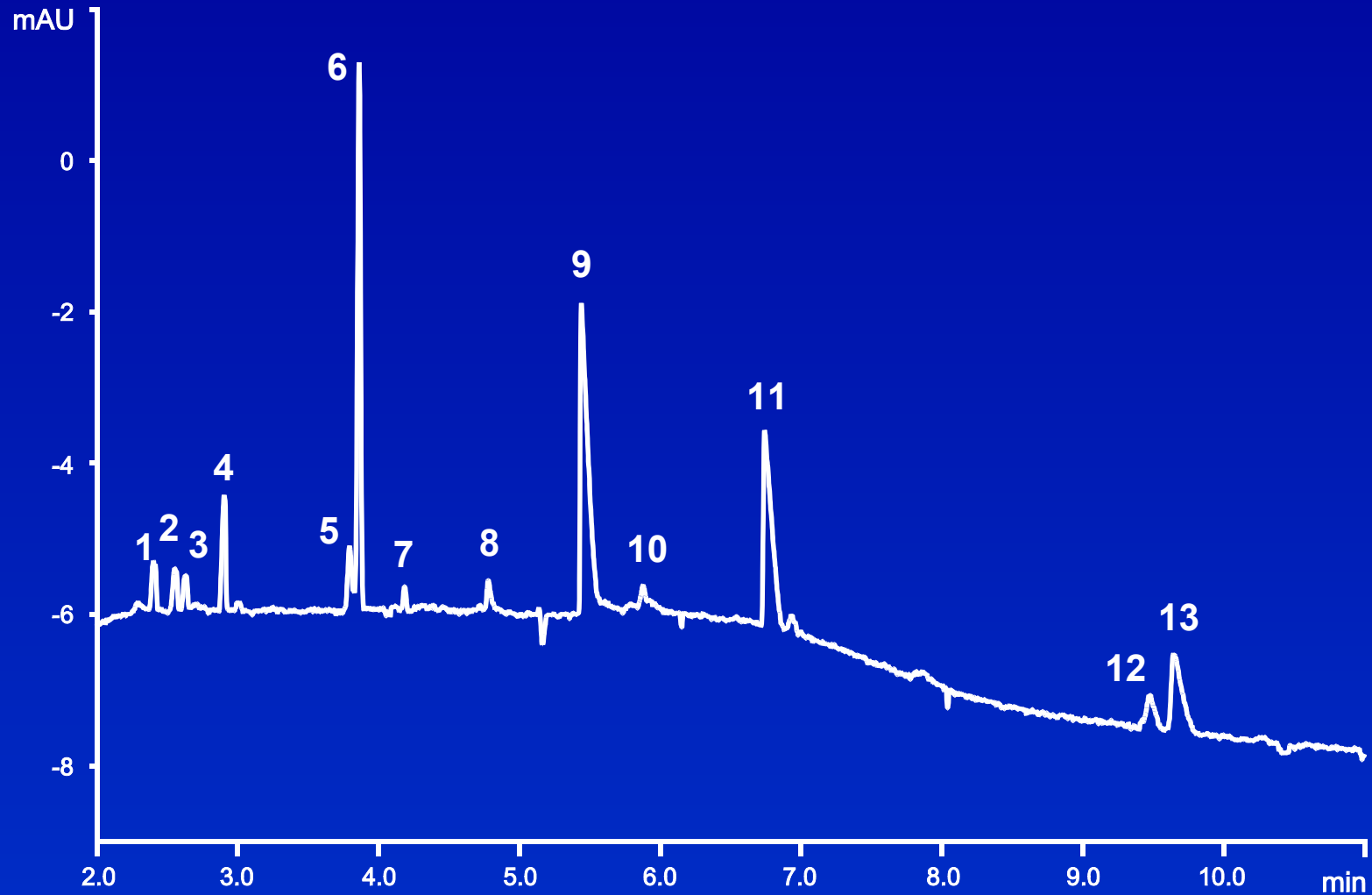


sampling



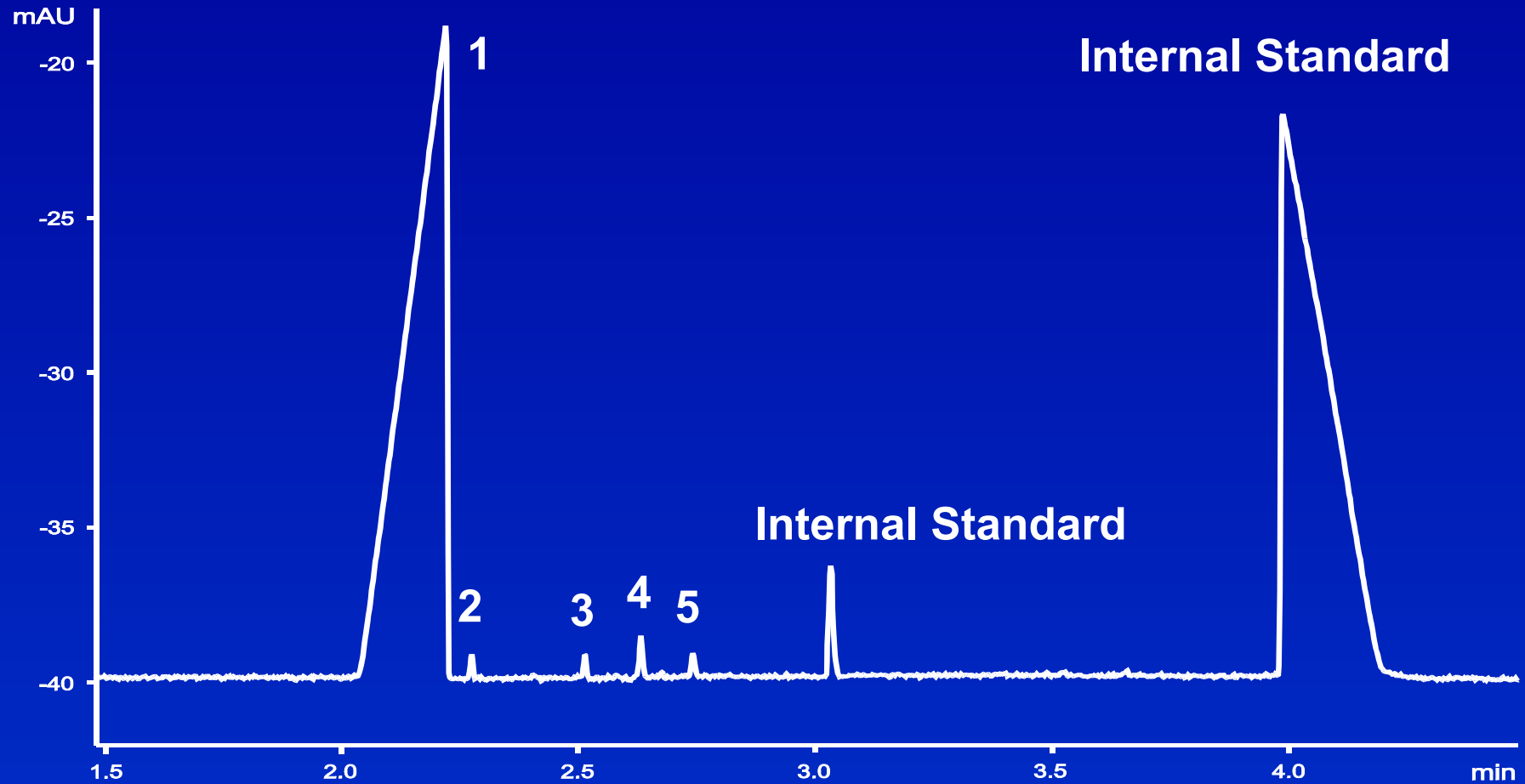
- extraction of a 300 mm wafer with 4 mL UPW containing internal standards
- extraction volume adjusted to wafer diameter
- LOQ of 2×10^{11} ions / cm² or approx. 16 pg / cm²

Anions due to WSWEM



1 chloride, 2 nitrate, 3 sulfate, 4 perchlorate = internal standard, 5 fluoride, 6 formate, 7 unknown, 8 phosphate, 9 carbonate, 10 methanesulfonate, 11 acetate, 12 propionate, 13 butanesulfonate

Cations due to WSWEM



1 ammonium, 2 potassium, 3 sodium, 4 calcium, 5 trimethylammonium

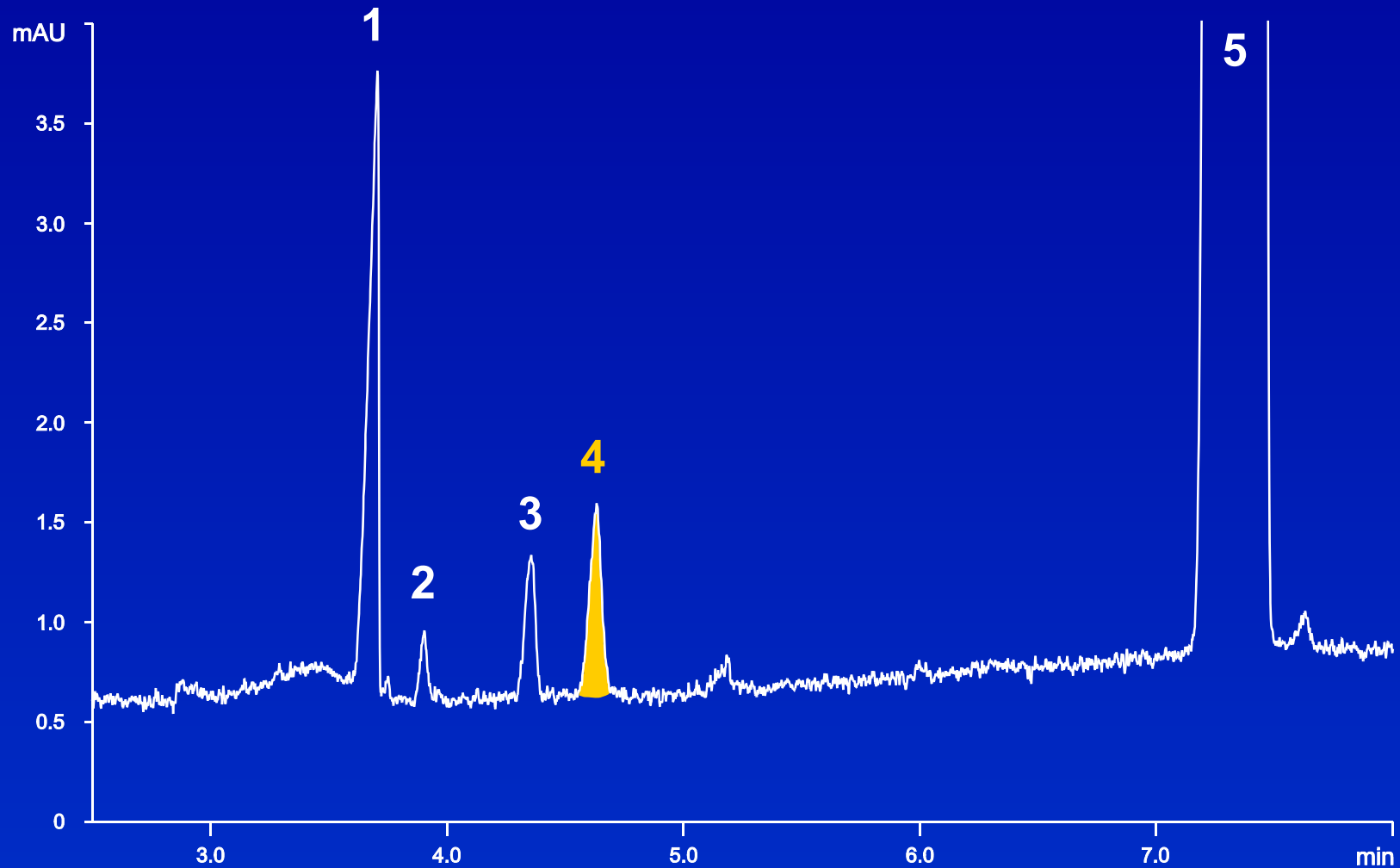
Wafer Surface Preparation by VPD

Vapor Phase Decomposition



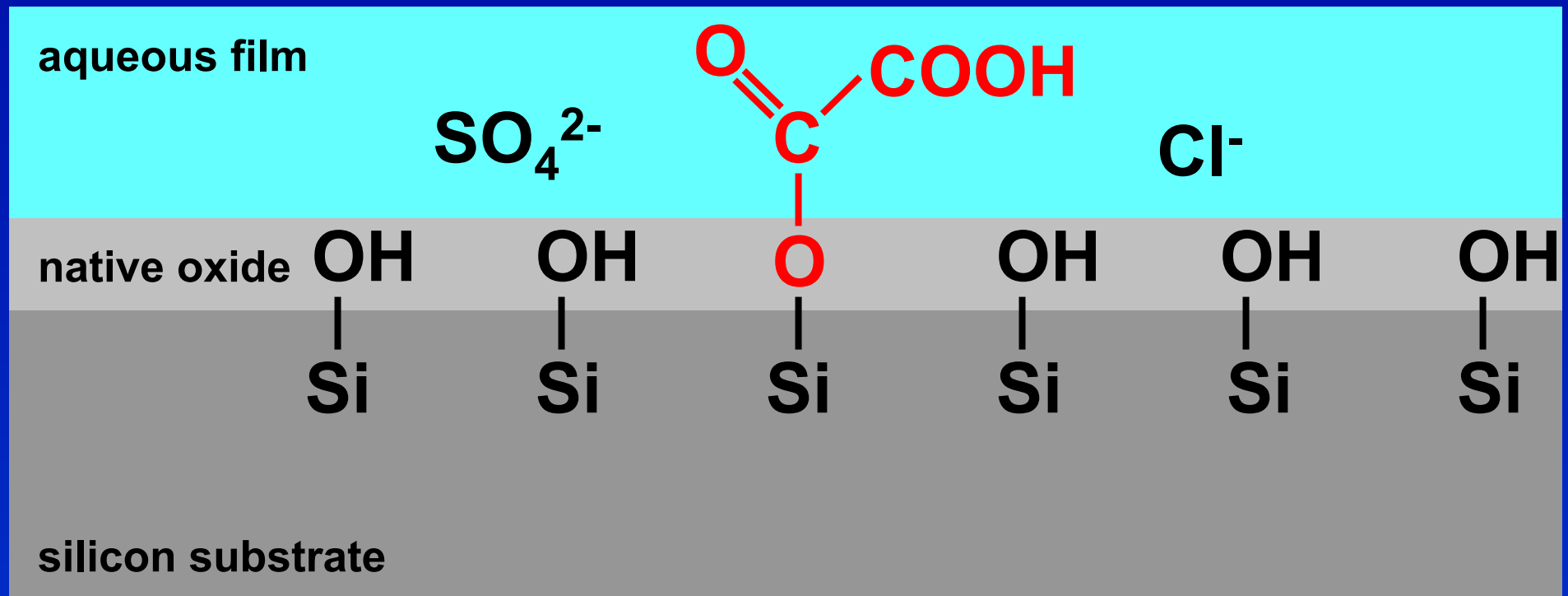
- native oxide layer SiO_2
- dissolving the native oxide layer
- soluble contaminants in fluorosilic acid
- integral wafer contamination can be collected in one droplet
- LOQ of 5×10^{10} ions / cm^2 or approx. 4 pg / cm^2 for 300 mm wafer

Anions due to VPD



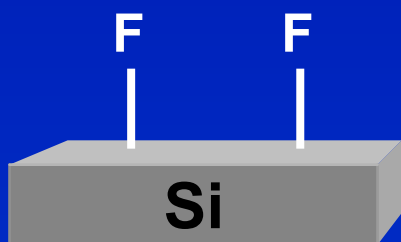
1 nitrate, 2 sulfate, 3 perchlorate = internal standard, 4 oxalate, 5 fluoride (from VPD preparation)

Assumed Binding of Oxalate

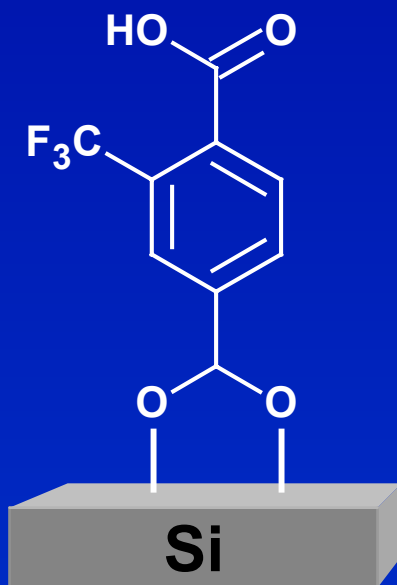


Adsorption of Dicarboxylic Acid and subsequent Chemical Reaction on Si Surface

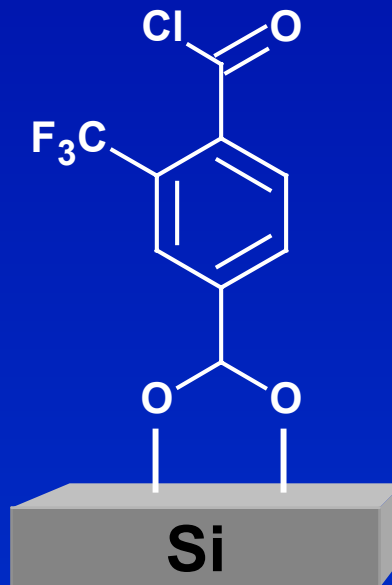
M. Mitsuya, N. Sugita, *Chemisorption of Dicarboxylic Acids on an Si(111) Surface and Subsequent Chemical Reactions at the Surface of Adsorbed Molecular Layers. Langmuir* **1997**, 13, 7075 - 7079.



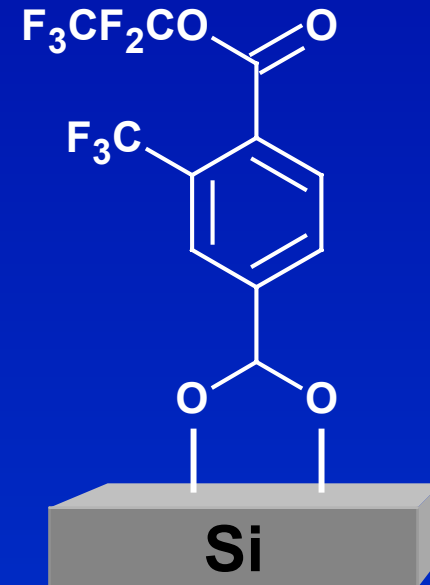
fluorine terminated
Si surface



as-deposited layer
of 2-(trifluoromethyl)
terephthalic acid

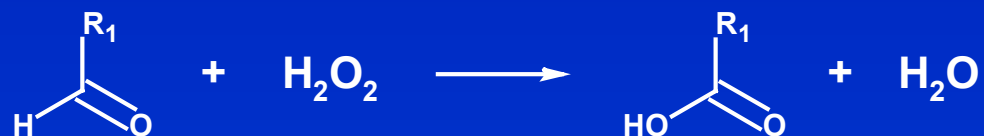
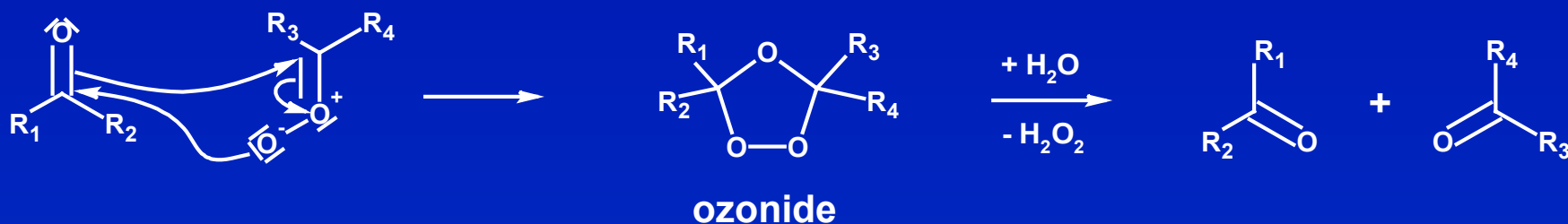
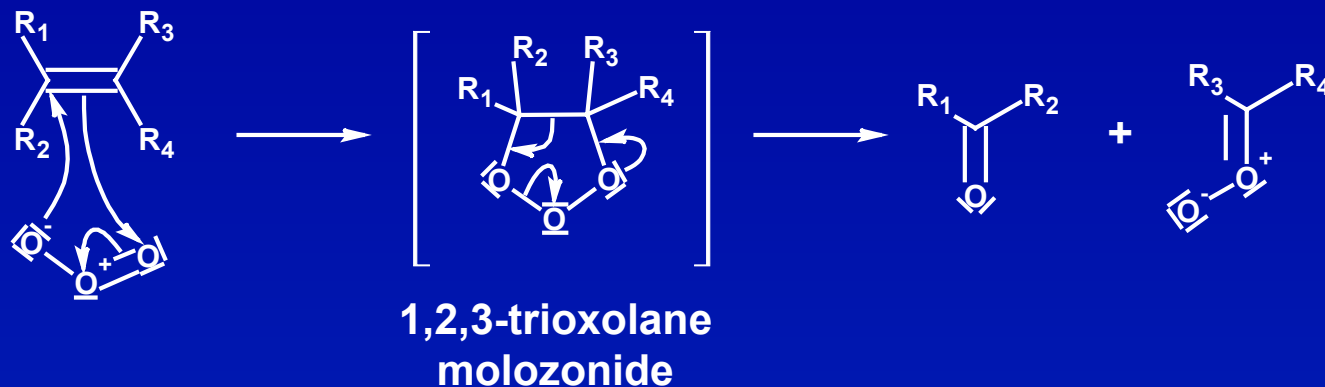


after chlorination with
thionyl chloride / hexa-
methylphosphoramide



after esterification with
2-(perfluorohexyl)
ethanol

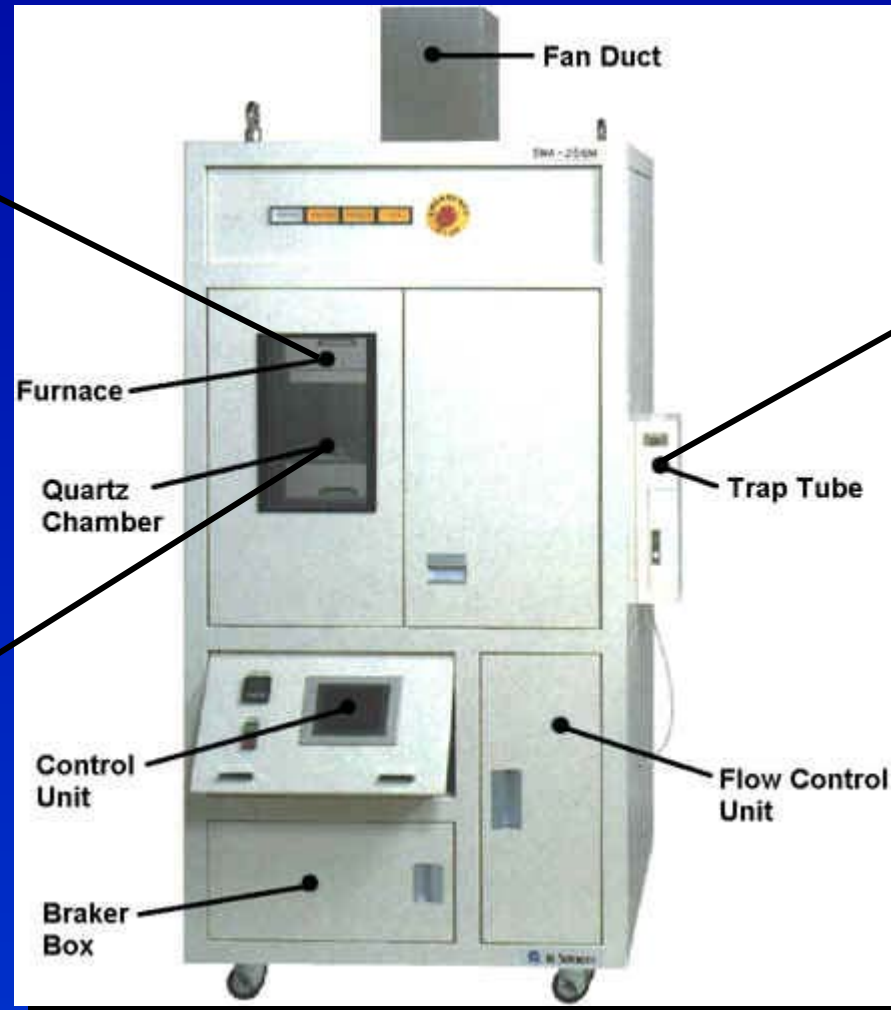
Ozonolysis in Organic Synthesis



Volatile Organic Compounds - VOC

- **Standards: ASTM F 1982-99 and SEMI E108-0301**
- **Silicon Wafer Analyzer SWA 256 from GL Sciences**
heat furnace for complete wafer up to 300 mm
- **Thermal Desorption of VOC's from Wafer Surface at 400°C**
- **Adsorption of VOC's on Sampling Tube (Tenax)**
- **Determination of VOC's by TD-GC/MS**

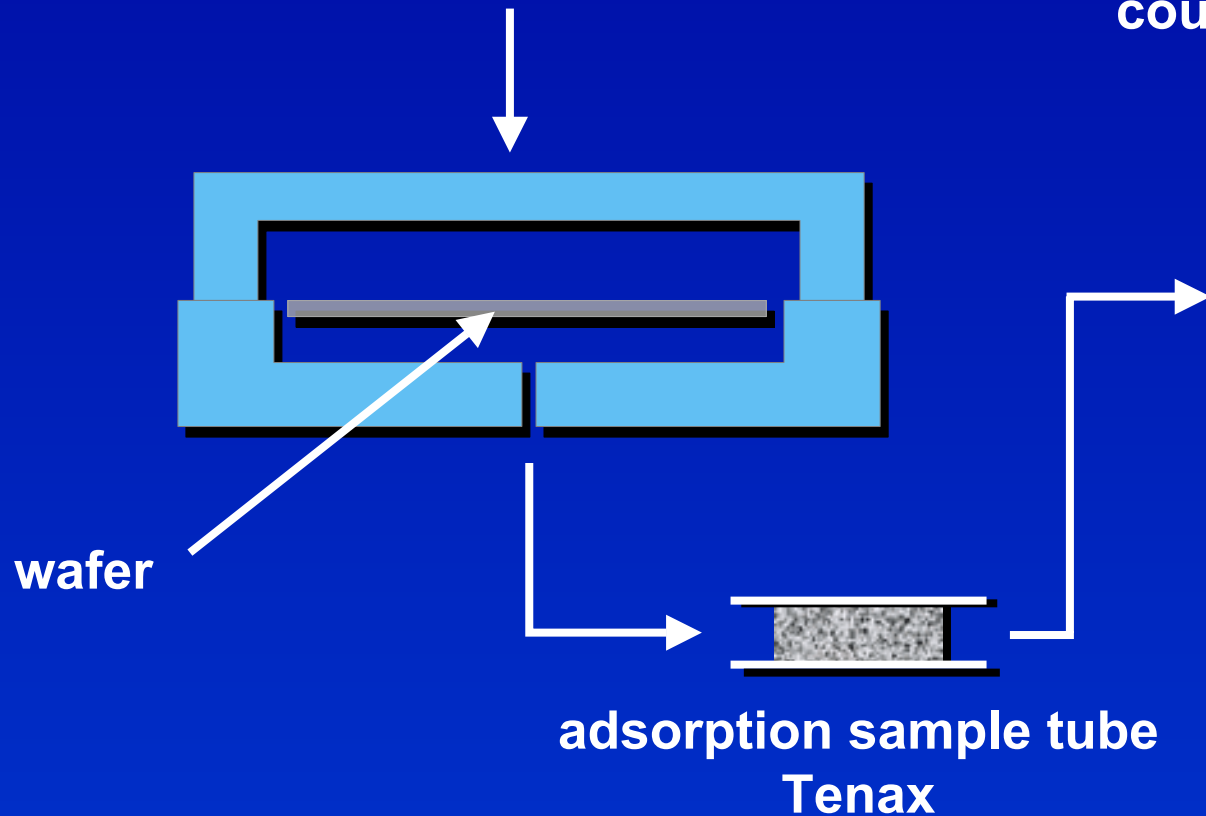
Surface Wafer Analyzer 256 M - GL Science



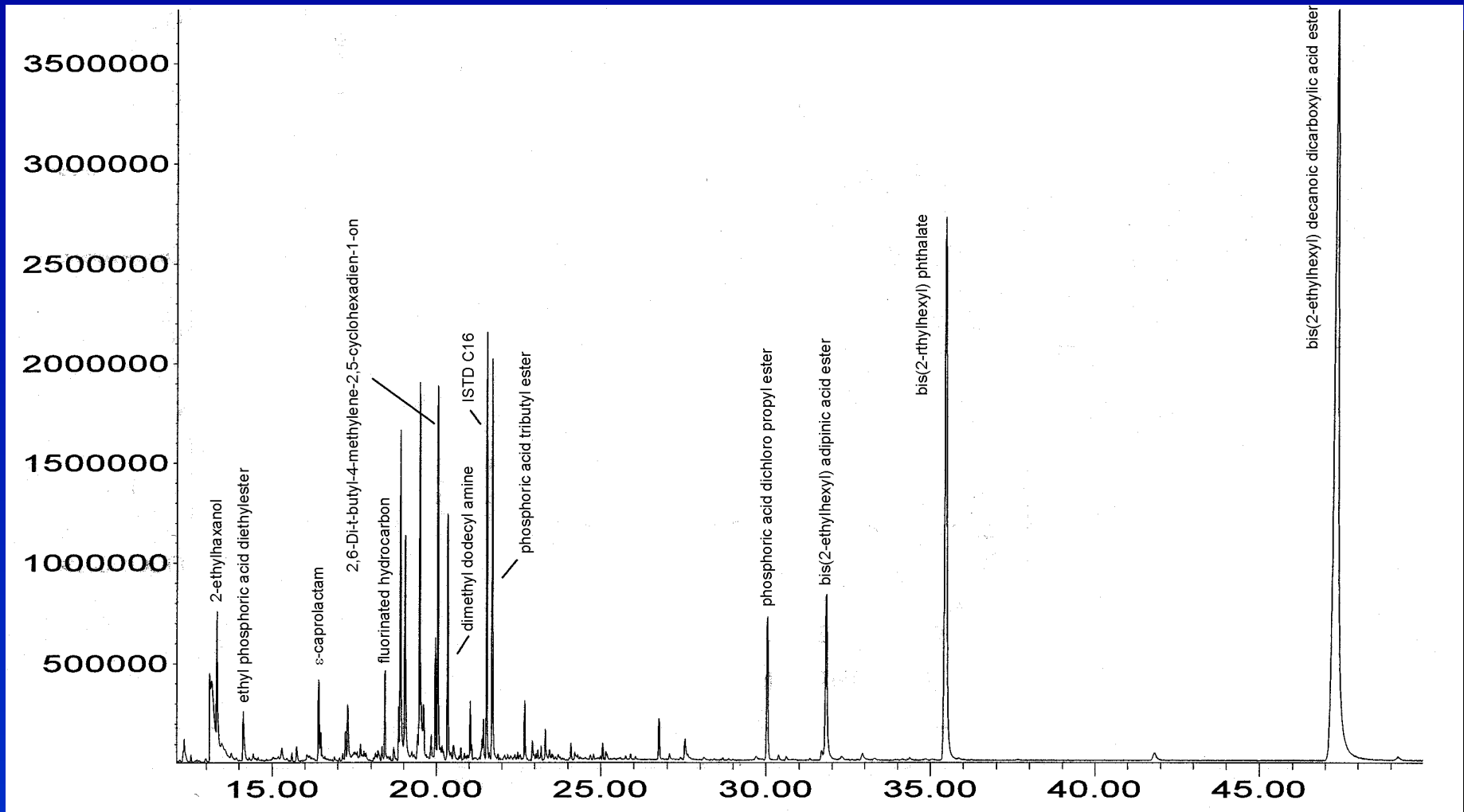
SWA 256 - TD-GC/MS

Silicon Wafer Analyzer - SWA 256

thermal desorption gas chromatography
coupled to mass spectrometry



VOC's on a Test Wafer exposed to Cleanroom Air for 72 h



Summary

- No single technique for monitoring organic
- Origin of organic contaminants very often ambiguous
- Effect of special molecule unclear

Much more R&D is necessary for an understanding of organics comparable to the knowledge of metal contamination.