

Real-Time Monitoring of Hazardous Air Pollutants in the Semiconductor Manufacturing Environment Using SIFT-MS

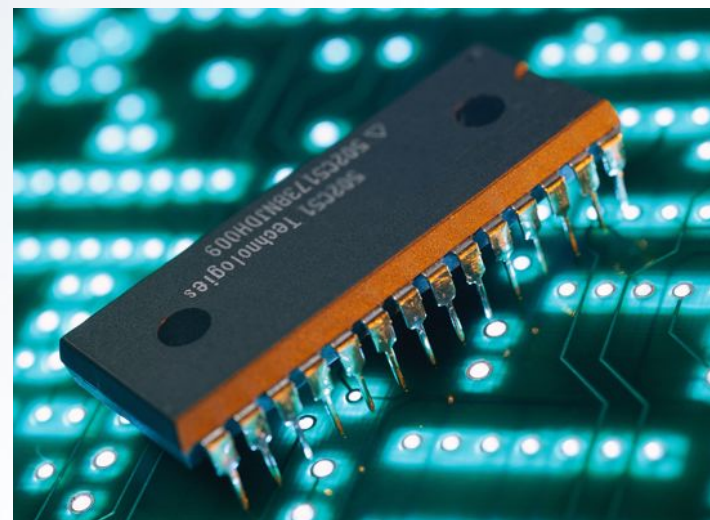


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Dr Vaughan Langford

Semiconductor Industry Applications of SIFT-MS

- Principles of SIFT-MS
- Analysis capabilities
- Air quality monitoring using SIFT-MS
- Key benefits of the Voice200[®] instrument
- Concluding remarks



Principles of the SIFT-MS Technique

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What is SIFT-MS?

- **Selected Ion Flow Tube – Mass Spectrometry (SIFT-MS)** is a form of direct mass spectrometry that utilizes *precisely controlled chemical ionization reactions*.
- SIFT-MS detects and quantifies trace amounts of diverse volatile organic compounds (VOCs) and certain inorganic gases
 - ... from **whole air**
 - ... in **real time**
 - ... with typical **detection limits at parts-per-trillion level** (by volume)
 - ... in a **single, convenient analysis**



The Syft Technologies'
Voice200®

SIFT-MS principles

SI

Reagent Ion Selection

Microwave plasma



Quadrupole mass filter



0.3 torr

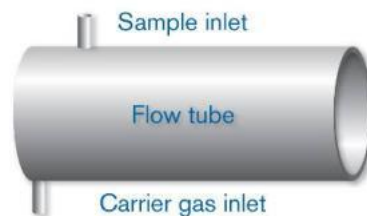
H₃O⁺
NO⁺
O₂⁺

10⁻⁵ torr

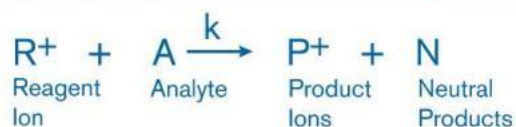
H₃O⁺
NO⁺
O₂⁺ } R⁺

FT

Analyte Ionisation



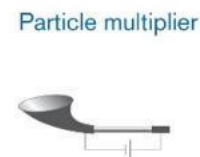
0.5 torr



MS

Analyte Quantitation

Quadrupole mass filter



10⁻⁵ torr

$$[A] = \gamma \frac{[P^+]}{[R^+] k}$$

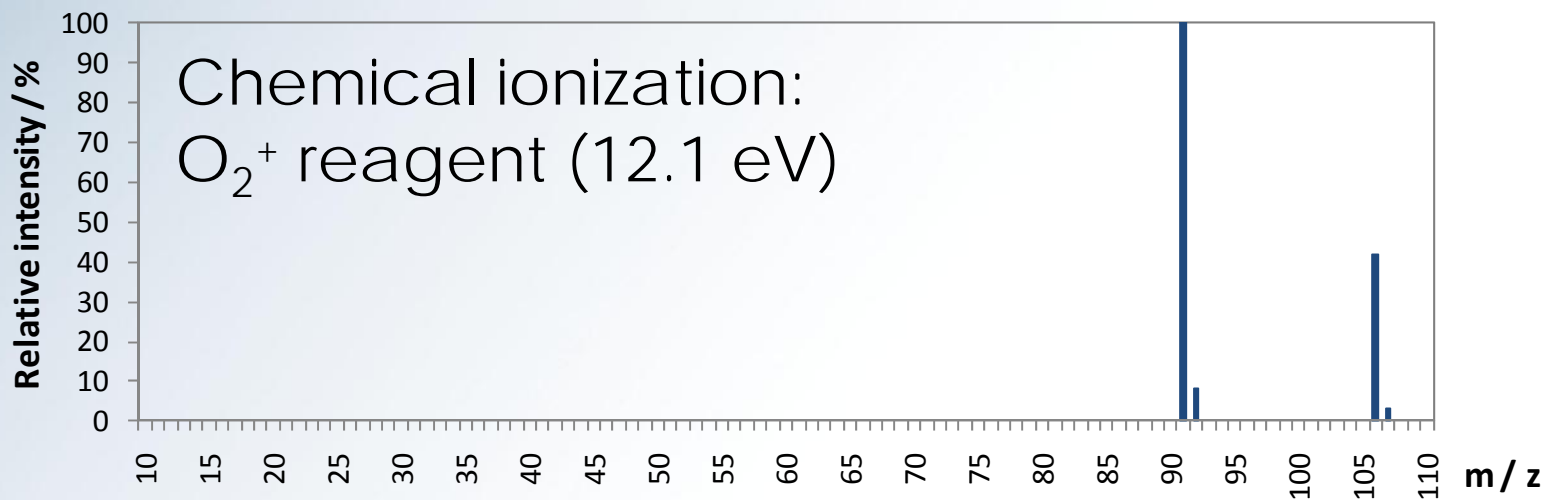
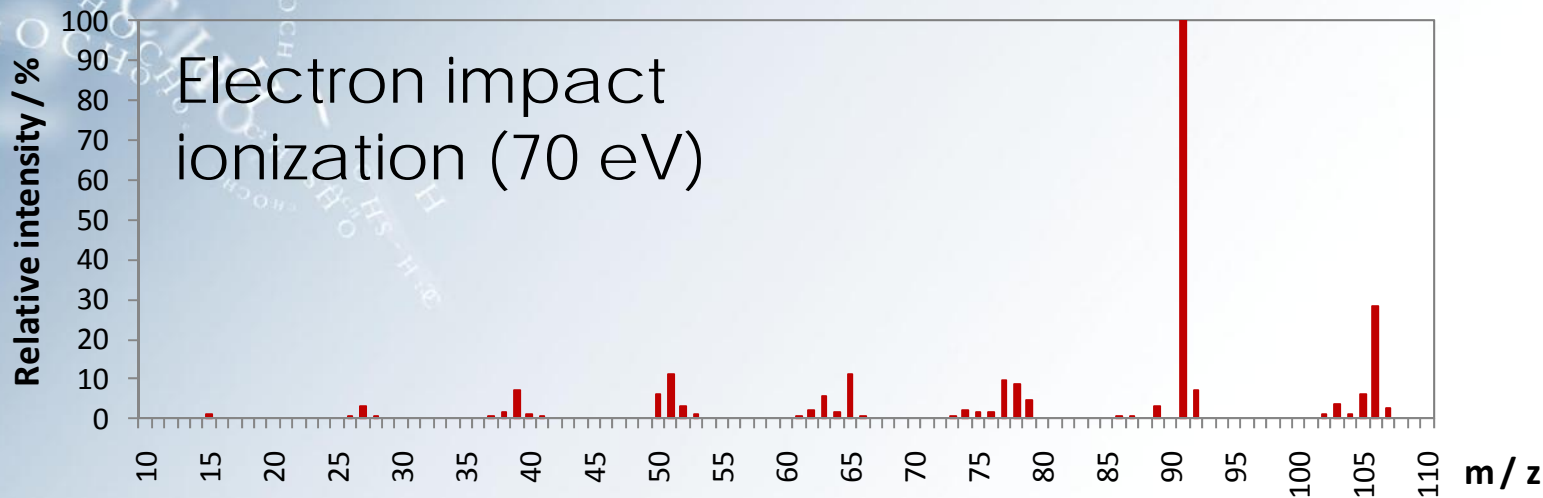
Instrument calibration factor

SIFT-MS CI compared with GC-MS CI and EI ionization

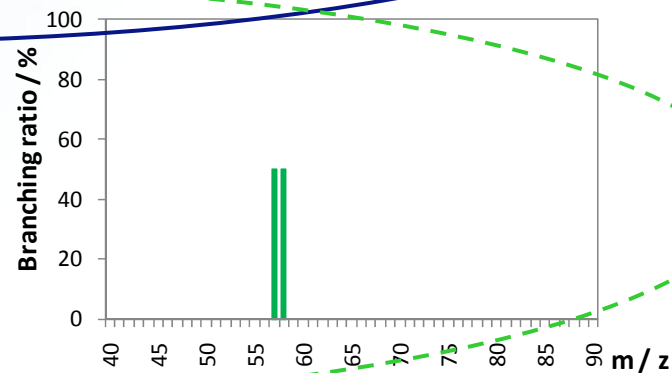
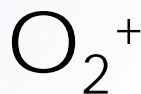
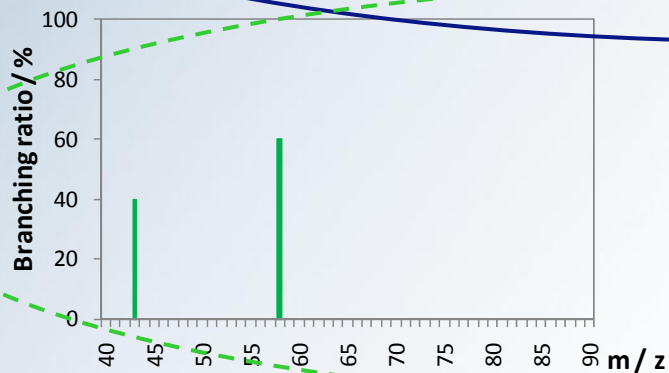
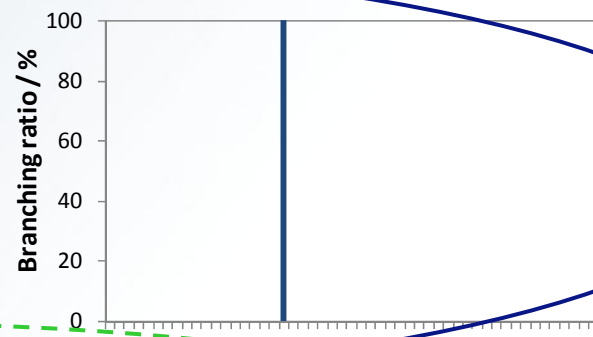
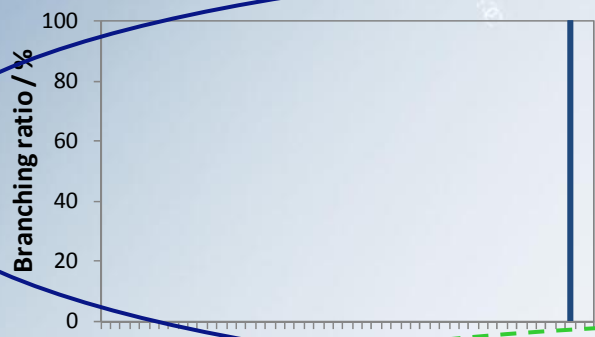
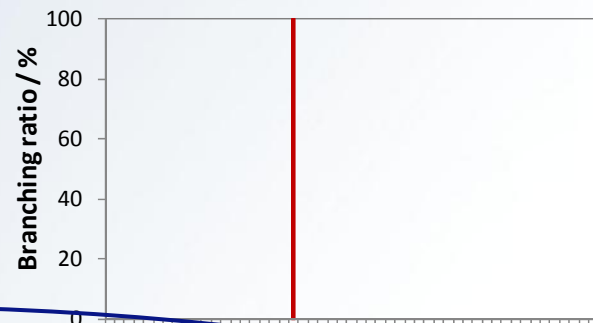


- SIFT-MS uses much softer CI agents than GC-MS (called “reagent ions” in SIFT-MS)
- This results in significantly *less fragmentation* than EI ionization and CI, making chromatography unnecessary and real-time analysis possible
- As a consequence, the compound “fingerprint” for SIFT-MS will generally be less specific than in GC-MS

Ethylbenzene using EI and CI (O_2^+)



Resolving acetone and propanal



SIFT-MS is able to resolve certain isobaric and isomeric compounds.

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Analysis Capabilities of the SIFT-MS Technique

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What types of samples can SIFT-MS analyze?

- SIFT-MS is a dedicated analyzer for trace reactive compounds in air
- Dry or humid whole air samples:
 - Outdoor/indoor air
 - Breath
 - Headspace above aqueous solutions or solids



Sample presentation to SIFT-MS

- A range of sampling methods are compatible with SIFT-MS whole air analysis:
 - Direct 'live' sampling of whole air
 - Gas sampling bags (e.g. Tedlar, Teflon)
 - SUMMA canisters



What compounds can SIFT-MS analyze?

General class	Example classes / compounds
hydrocarbons	alkanes, alkenes, aromatics
oxygenates	alcohols, aldehydes, ketones, esters
nitrogen compounds	amines, amides, nitriles
sulfur compounds	mercaptans, thioethers, carbonyl sulfide
halogenated compounds	freons, perfluorocarbons, aliphatic and aromatic fluorides and chlorides, etc.
organosilicon cmpds	siloxanes, silanes
organophosphorus compounds	organophosphates, organophosphites
inorganic compounds	ammonia, chlorine, hydrogen sulfide, phosphine, selected inorganic acids and boron compounds

The Voice200[®] as a Tool for Air Quality Monitoring

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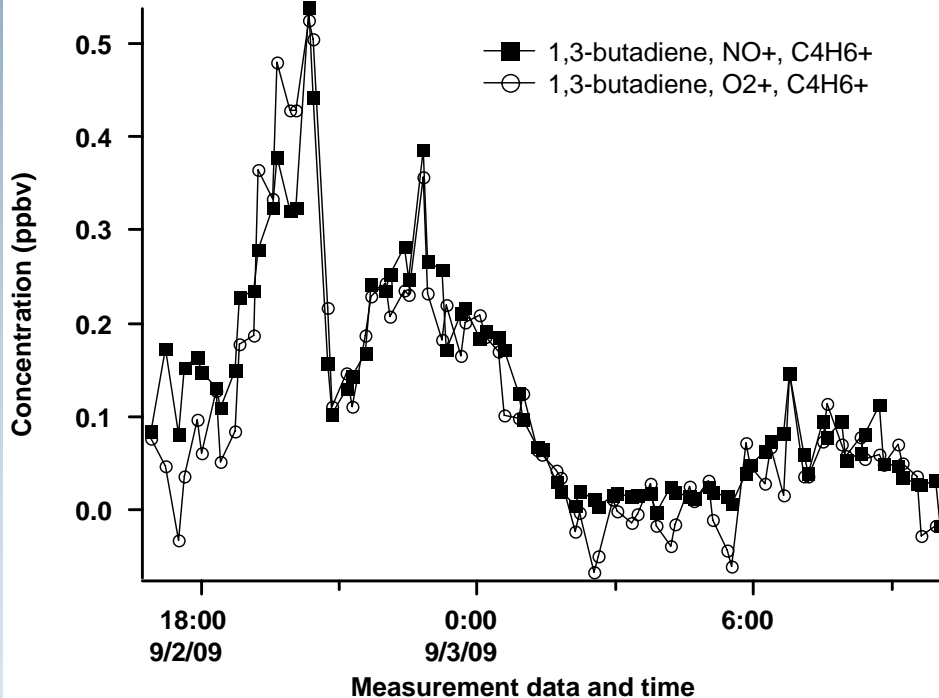
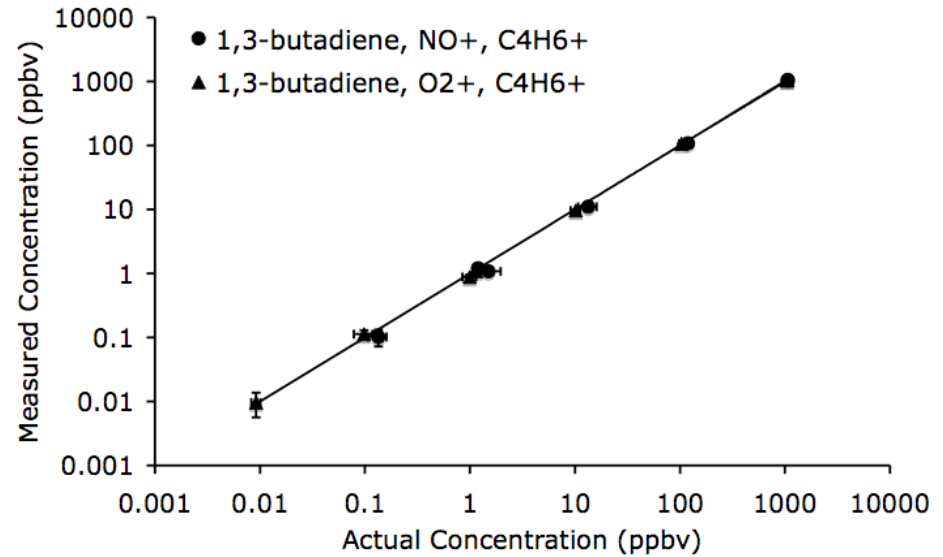


Why SIFT-MS?

- The capabilities of SIFT-MS make it an ideal solution for protecting:
 - Worker health
 - Product quality
 - The environment
- Relevant industries include:
 - Semiconductor fabrication
 - LED panel manufacture
 - Solar cell fabrication



Real-Time Air Monitoring



- The graphs show results for **butadiene** for two product ions:
 - linearity (above)
 - ambient air analysis at the Syft head office (Christchurch, New Zealand).

Stack Emission Analysis



- Ability to monitor stack emissions directly in stack via a suitable sampling arrangement
- Unique flexibility of SIFT-MS also enables the same instrument to make measurements at site boundary

Occupational Safety and Health



- Fumigants
- Toxic industrial chemicals

Fast, simple, accurate and economical

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Example of detection of toxic compounds: fumigants



Phosphine

Hydrogen cyanide

Sulfuryl fluoride

Methyl bromide

Chloropicrin

Ethylene oxide

Ethylene dibromide

- All container fumigants are harmful to humans
- Some are lethal at very low levels
- Containers may have a far larger dose of fumigant applied than is recommended
- Residual fumigants create a hazard for workers entering the containers
- Employers have a legal responsibility to protect workers.



The Syft solution-based approach

- Robust design
- Solvent-free
- Cheap to run
- Very fast (typically 1 minute per sample)
- Simple to operate (touch screen)
- Repeatable analytical-grade results

Scan Results		voice200®
Fumigant Analysis		⚠
ID 122156	03-04 12:23	Menu
formaldehyde	2.6 ppm	⚠
phosphine	<RT	
ethylene oxide	<RT	
ethylene dibromide	<RT	
chloropicrin	<RT	
hydrogen cyanide	<RT	
methyl bromide	<RT	
vikane	<RT	

Results displayed on the Voice200® instrument

Sample case



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Key Benefits of the Voice200[®] Instrument

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Syft Voice200[®] automation and remote access



- The Voice200[®] continually monitors its own performance
- Fully automated validation cycles (usually done once per day) ensure that analysis is valid
- The Voice200[®] is network-ready can be operated from any location with internet access

Syft Voice200[®] durability and mobility

- Syft's instruments are installed in industrial applications (such as in warehouses and vans*), as well as in laboratories
 - Within a facility, they are easily maneuvered using their built-in wheels
- * The instrument can obtain quantitative data 15 minutes after being moved to another location!



Software: Voice200[®] instrument

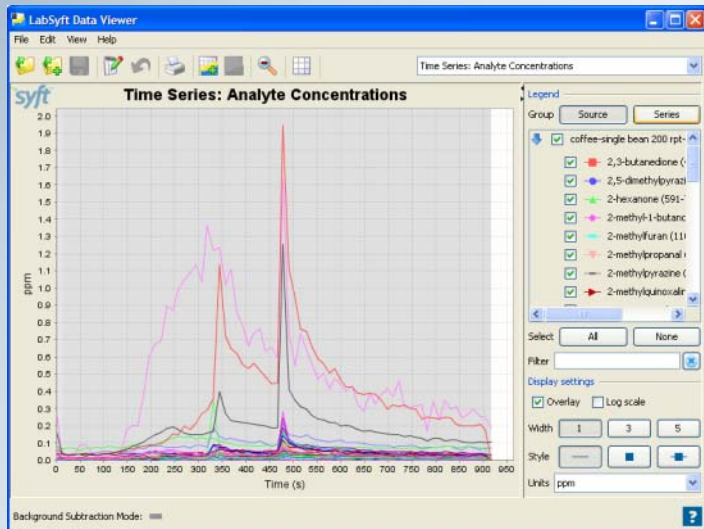
- Designed for use by non-technical operators
- The Voice 200[®] instrument's software has several primary functions:
 - Controlling the instrument
 - Validating that the instrument is operating within specification
 - Running methods to analyze samples; compute and present results

Scan Results		voice200 [®]
A Fumigants (quick)		⚠
ID 122389		06-18 10:01
ethylene dibromide	13000 ppm	⚠
phosphine	<RT	
hydrogen cyanide	<RT	
formaldehyde	<RT	
ethylene oxide	<RT	
methyl bromide	<RT	
chloropicrin	<RT	
sulfuryl fluoride	<RT	

Software: LabSyft



- The Syft LabSyft software package operates on a remote computer and is designed for advanced users
- LabSyft allows users to:
 - View data as it is generated
 - View and manipulate data after scan completion
 - View, search and expand the compound library
 - Create and edit analytical methods
 - Set up batch analyses



Concluding Remarks

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Benefits of Syft SIFT-MS technology

- Sensitive, real-time analysis without preconcentration
- Diverse chemicals can be analyzed in a single run customized to meet customer's needs
- Mobile with rapid start-up
- Simple operation
- Low maintenance and low operating costs



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Why choose SIFT-MS over GC-MS?

- Readily configured for use by non-technical people (“user friendly”)
- Reduced maintenance
- Get laboratory-grade analyses faster because...
 - Chromatography is eliminated
 - Minimal or no sample preparation is required
- Long-term calibration stability because...
 - Precise ionization control is used
 - There is no chromatographic column
 - The ion source and detection system is very clean

Thank you for your attention.

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